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**Eco Design Implementation
Across the British Product Design Industry**

Doctor of Philosophy (PhD) Thesis

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To Dad.

Abstract

Our understanding of the effects that human production and consumption has on our planet and its resources has challenged us to think differently when developing new products. In response to these problems, Eco Design has been developed over the last few decades. Eco Design is a process integrated into product and engineering design that aims to lower the environmental impact of products across their life cycle, whilst not hindering design brief criteria such as function, price, performance, and quality.

Research in Eco Design has focused mainly on the development of new tools and ways to implement Eco Design in industry. However, there is still little empirical knowledge today regarding the state of Eco Design implementation and practices in industry; in addition to the prerequisite needs and factors to successfully implement Eco Design.

The aim of this research has been to review the level and type of Eco Design in the British Product Design industry and to identify recurrent themes helping or hindering implementation. This was achieved through the use of a pilot study followed by a two stage case study design, involving 20 cases and 57 participants across 65 interviews. The investigation and its analysis produced 12 confirmed themes, each generating their own drivers and barriers to Eco Design implementation.

This research into Eco Design implementation provides a unique contribution and a timely insight into the Eco Design practices of the British Product Design industry today. The research also provides the novel contribution of identifying the drivers and barriers to implementing and sustaining Eco Design, as well as an understanding of the strengths and shortfalls of the current Eco Design processes and tools. These contributions to knowledge in the field of Eco Design will help future research formulate better solutions to implement Eco Design processes in the Product Design industry.

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Publications

Journal Papers:

- FORD, P. and RADLOVIC, P. (2013) Design, Sustainability and the Supply Chain: Design Underpinning Sustainability. *The International Journal of Sustainability Policy and Practice*, 8 (1), pp. 233-246.
- RADLOVIC, P. and FORD, P. (2013) Collaboration Barriers in the Implementation of Design for the Environment: Case Studies from Small and Medium UK Enterprises. *The International Journal of Environmental Sustainability*, 9 (1), pp. 1-6.
- RADLOVIC, P., LEMON, M. and FORD, P. (2013) Design for the Environment in UK Product Design Consultancies and In-house Design Teams: An Explorative Case Study on Current Practices and Opinions. *The International Journal of Design Management and Professional Practice*, 6 (2), pp. 73-83.

Conference Paper:

- RADLOVIC, P. (2013) Education, Materials, Sustainability: Joining the Dots. *The Minerals, Metals and Materials Society Conference, REWAS 2013 Enabling Materials Resource Sustainability, San Antonio, March 2013.*

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Chapter 1 - Introduction

“Industrial development of the past 200 years has brought immeasurable wealth and prosperity. However, it has also caused unintended ecological degradation. As a result, the earth faces many environmental problems, including global warming, ozone depletion, deforestation and desertification, declining biodiversity, acid rain, industrial accidents, and toxic wastes.” (Shrivastava, 1995, p.936)

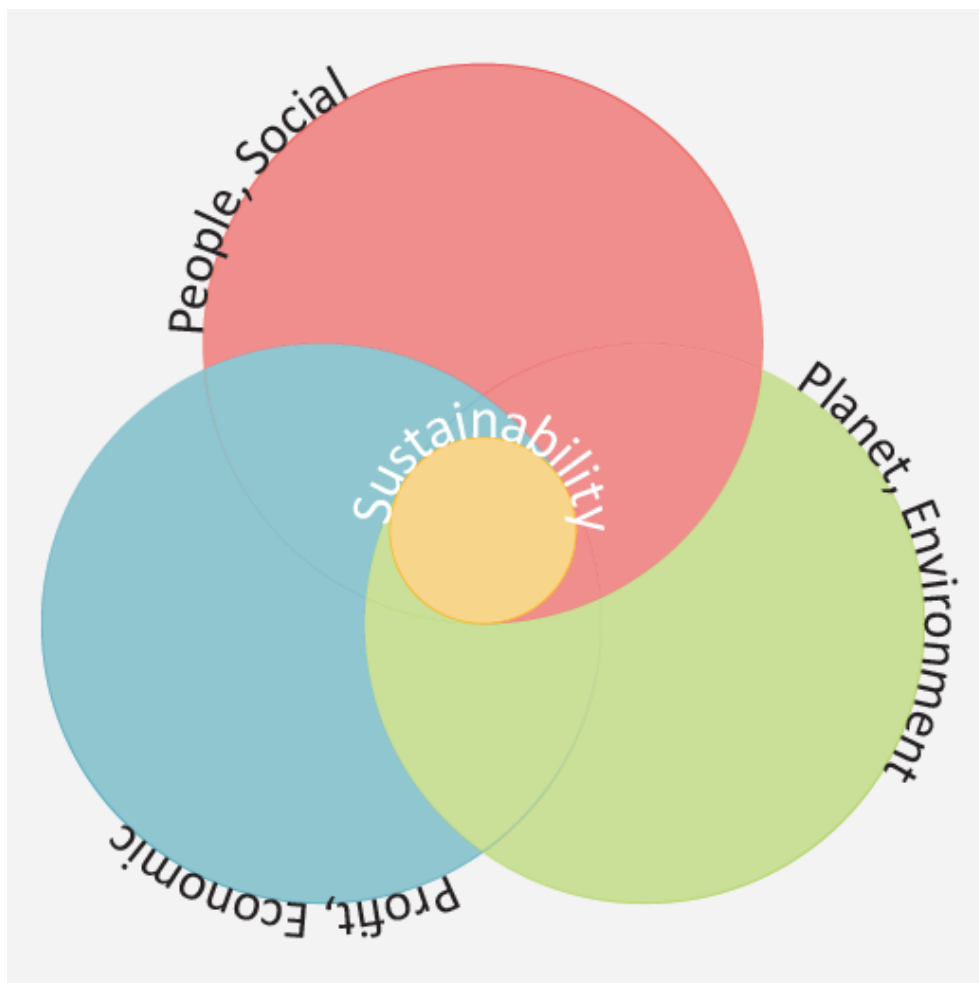


Figure 1.1 – The triple bottom line (original work).

This first chapter presents an overview of the wider context surrounding Eco Design, as well as a background understanding for taking up this research. The first section details the researcher's motivations for undertaking this research, while the second and third sections present an introduction to Sustainable Development as a phenomenon and of its repercussions in terms of policy and industry changes. The fourth and fifth sections introduce the role of design in achieving Sustainable Development and introduce Eco Design as a discipline. The sixth and seventh sections then describe the current shape and size of the Product Design industry and the need for empirical research on the practices of Eco Design. The last two sections present the research aim, objectives and contributions, as well as the research and thesis structure.

1.1 Personal Background and Motivations

This section introduces the researcher's position and background; providing an understanding of the underlying motivations for this research and of subsequently, the audience that the thesis is directed at.

This research is about the real-life practices and experiences of product designers in their journey towards Eco Design implementation. To understand the motivations for this research, the researcher's background needs to be put into perspective. While the aim of this research is to provide a timely understanding of Eco Design implementation; the motivation for the research originally stemmed out of the researcher's own experience studying then practicing Product Design and Eco Design. This industry experience resulted in doubts towards the efficacy of the Eco Design implementation methods developed by academics, and a belief that there was a noticeable disconnection between the practitioners' need for help and

the academic world offering in terms of Eco Design implementation approaches, methods and tools.

As a result, this research was devised and undertaken to provide a practical and pragmatic perspective of practitioners' experience in Eco Design implementation. And as such, this research represents the practitioners' view to communicate and analyse their stories, efforts and difficulties. This in turn provides context to an academic field that relies largely on theory (Baunmann, 2002); but also helps other practitioners understand and formalise the barriers to implementation they encounter. As such, this research is aimed for both the Eco Design related academic fields and for all Product Design practitioners.

1.2 Sustainable Development

This section presents the emergence of Sustainable Development as a political and societal concept. It describes the origin of the discipline, using the most original sources available, before providing context on the growth of the derived academic discipline.

Sustainable Development is a political concept that emerged in the 1970's when the public and governments started to understand and worry about the effect of human activity on the environment, the potential consequences of depleting resources for future generations and the permanent damage caused to the environment. It became increasingly clear that the rate of resource depletion was directly linked to the production of the goods needed to satisfy our consumption patterns; and that such a rate of depletion, combined with a growing population, was creating an unsustainable stress on the environment.

"Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (World Commission on Environment and Development 1987, p.8)

Although it has been defined in many different ways since the 1970's; this definition from the World Commission on Environment and Development remains one of the first and most widely quoted. The definition usually precedes the concept of the triple bottom line that refers to the economic 'bottom line', adding to it an environmental and a social bottom line (see figure 1.1). This idea of three axes to Sustainable Development was developed at the United Nations Conference on Environment and Development (UNCED) in 1992. The resulting published document states: *"Prevailing systems for decision-making... tend to separate economic, social and environmental factors... An adjustment or even a fundamental reshaping of decision-making... may be necessary... in effect achieving a full integration of these factors."* (United Nations Division for Sustainable Development, 1992, Chapter 8). Following these events, in 1994, Elkington coined the term 'triple bottom line' (Elkington, 2001). The UNCED conference, also called the 'Rio Earth Summit', was the first worldwide event to bring thousands of people and world leaders together to tackle issues surrounding Sustainable Development. Events and developments like the ones of the 'Rio Earth Summit' had considerable repercussions in both academia and industry. The discipline of Sustainable Development was born.

Looking at the literature output in this area is a good way to grasp when the discipline emerged and how it grew over the years. Sutcliffe et al. (2009) demonstrate this phenomenon, by showing the dramatic increase in publications on the topic of Sustainability, since the beginning of the 1990's (figure 1.2). However, this numeric increase alone may give a false sense of growth through the use of a keyword with such a wide meaning. Figure 1.3 adds to this picture by showing the papers (from the Web of Knowledge database, Thomson Reuters, 2013) published each year in the five most cited academic publications (h5-index) of the Sustainability field (Google, 2013). This figure clearly correlates with figure 1.2, showing a dramatic increase from the beginning of the 1990's. Baumann et al. support these findings, however drawing attention to the fact that *"the strong increase from 1990 may be somewhat biased since some of the databases used for getting the references were started in that year"* (2002, p.411). Figure 1.3 however shows the dramatic increase continues even stronger after the 1990's. Finally, even accounting for the 2.5% overall academic growth of publications across fields

(National Science Board, 2010); the strong increase in the field of Sustainability remains conclusive.

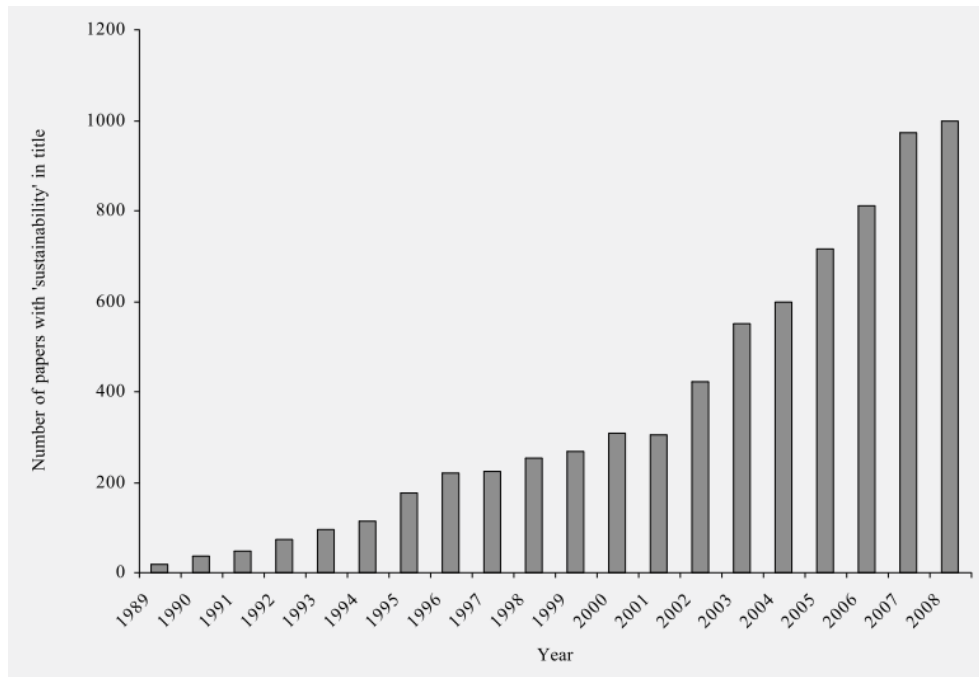


Figure 1.2 – Papers in SCOPUS database with 'sustainability' in the title, (Sutcliffe et al. 2009, p.3).

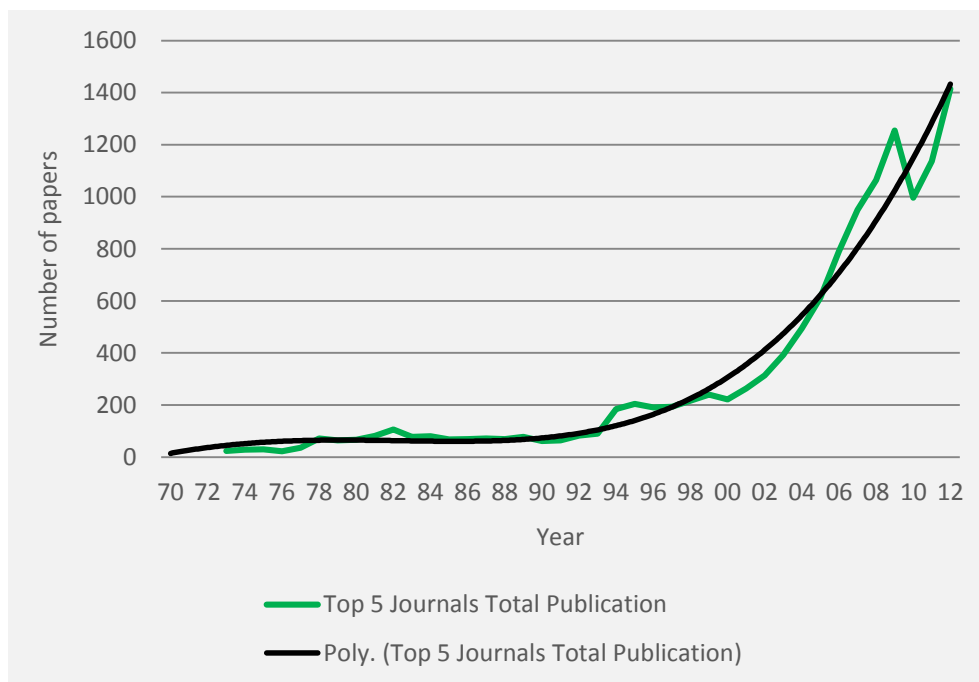


Figure 1.3 – Papers in Web of Knowledge database published in the five most cited academic publications (h5-index), with overall polynomial trend line (original work).

Regarding the concept of triple bottom line, Sutcliffe et al. (2009), demonstrate disparities between the development of the different environmental, social and economic bottom lines (figure 1.4). They explain that: *“It is perhaps unsurprising that environmental sustainability is the most developed of the three areas since much work on sustainability was born out of the green movement of the 1970s”* (p.5). This is also true considering that the principle of the other bottom lines (especially social) was only developed as a sole concept in the 1990’s. Finally, Handfield et al. (1997) describe a similar growth of interest in industry and provide interesting parallels showing how the take-up of those issues by industry follows the growth of environmental regulations.

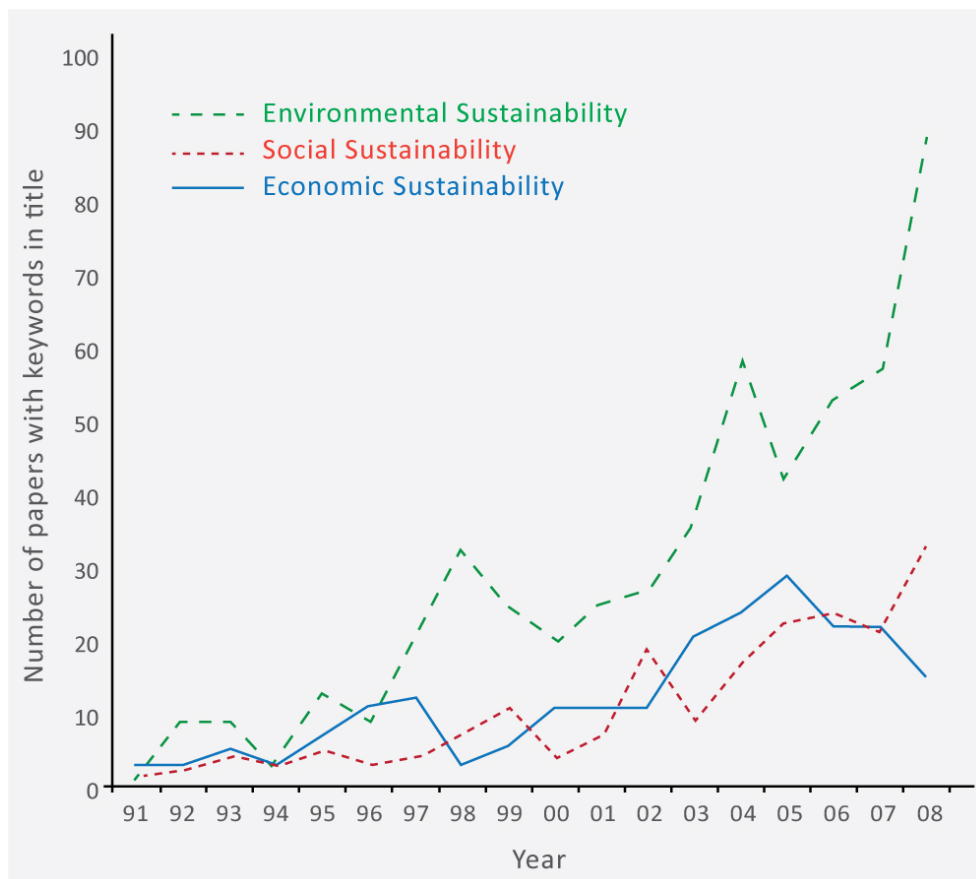


Figure 1.4 – Number of papers in the SCOPUS database between 1991 and 2008 with the words ‘environmental sustainability’, ‘social sustainability’ and ‘economic sustainability’ in the title (Sutcliffe et al. 2009, p.5) (adapted).

Today, Sustainable Development is still a topical issue. Twenty years after the first Rio summit of 1992, the 'Rio+20 Earth Summit' was bigger than its predecessor although arguably less focused, representing the strong but divided trend of Sustainable Development (Vidal, 2012). While the world faces more than ever problems with ecological degradation, climate change and unsustainable resource consumption patterns; nations are divided on how to solve these issues without compromising on their own economic development. This has been especially true within the last few years. The worldwide economic downturn has had negative effects on nations' and industry's sustainable actions, with, for example, changes brought to the Kyoto protocol (Clark, 2012). These effects also trickled down to national and regional levels, with the suppression of QUANGOS (Quasi-Autonomous Non-Governmental Organisation); such as Envirowise (the main British governmental body set to help businesses act on environmental problems and resource efficiency) and the suppression of many regional supporting bodies (with the end of regional development agencies).

1.3 Socio-Economic Repercussions

While the previous section provided an overview to Sustainable Development; this section presents its socio-economic repercussions and the relationship between consumption, growth and Sustainability.

As introduced in the previous section, the Sustainable Development phenomenon stemmed from concern with our ever-increasing rate of resource consumption and therefore depletion.

This increasing rate of consumption is linked to different aspects. First, it is due to the unprecedented rate in population growth over the last century (from 1 billion people in 1804 to 2 billion in 1927 to over 7 billion in 2012 (UNPD, 2015)). However, this alone does not explain the growth rate of resource consumption.

Indeed, while the world population has significantly grown in recent times, over 80% of the world's resource expenditure comes from the richest 20% of the population (UNEP, 2011). One fear is that the other 80% of the population will develop to require the same resource consumption need as the current top 20%, leading to an even more unsustainable situation.

Our increasing rate of consumption is secondly linked to a more societal and economic need for growth. Capitalist nations rely on economic growth to thrive. Increasing economic growth is translated by increasing production outputs and therefore increasing rates of resources consumption.

However, the resources available on earth are finite. This is of course a problem for non-renewable resources, such as oil or ores, which simply become rarer and harder to extract. But this is a problem for renewable resources too. While renewable resources (for example timber) can be managed and replenished to be sustainably used indefinitely; this is only the case if the rate of consumption/depletion is not greater than the rate of replenishment. This means our rate of resource consumption cannot increase indefinitely and that our global need for growth cannot be achieved forever.

In other words, our societal need for economic growth needs to be met through other ways than goods production and resource use only (Sorrell and Ockwell, 2010). Governments have been seeking to do this by developing policies aiming to decouple economic growth from resource use and environmental impact (see figure 1.5). However, this is a global and complex task that requires all nations to participate. Taken in isolation, certain developed countries can be seen as succeeding in this matter (e.g.: Germany and Japan), but this is only because the goods production intended for those countries is exported to other nations (UNEP, 2011).

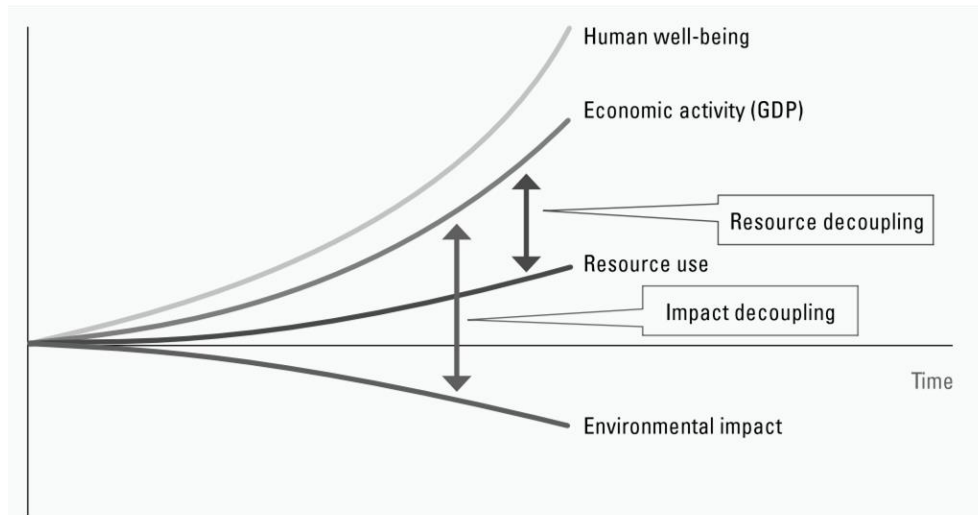


Figure 1.5 – Stylized representation of resource decoupling and impact decoupling (UNEP, 2011) (adapted).

Environmental policy efforts in Europe, for example, started in the 1990's with policies aiming to reduce the emission of pollutants (such as sulphur dioxide and nitrogen dioxide). This was followed in the 2000's by regulations aiming to reduce landfill waste (including electronic equipment waste) and the use of hazardous substances (Johnson, 2014). Later in the 2000's, the policy focus took a more proactive stance, and shifted its attention from waste and pollution management towards the design phase of goods production. The Ecodesign Directive was subsequently introduced in 2005, setting requirements to producers to design products with energy use and recycling content constraints (European Parliament, 2005).

Overall, these issues have had great repercussions for industry and actions have stemmed from different sources of pressure (push) such as legislation, consumers, competitors, rise in price of raw materials and waste disposal (Wilkinson et al., 2001). Additionally, organisations have started to follow the incentives (pull) of cost savings, market differentiation and improved brand image (using the topic of Sustainability as a marketing tool). The take-up of these issues in industry is explained by increasing pressures and incentives summarised by Angell: *“External pressures stem from legislation, accidents, local communities, competitors, “green” customer and investment groups, media, activists, scarcity of raw materials, and the rising costs of waste disposal. Internal pressures come from*

a heightened environmental awareness among employees, a perceived opportunity for waste and cost reductions, and a broadening definition of quality and service to include "cradle-to-grave" product and process responsibility." (2000, p.124). The diversity of these pressures and incentives to become more sustainable reflects the interdisciplinary nature of the issue, *"evident from the variety of fields in which researchers and practitioners are considering the challenges and implications of sustainability"* (Linton et al. 2007, p.1075).

While they have been pushed to consider sustainability issues; businesses have been divided as to whether there are real incentives to embrace them. Some feel there is a certain dichotomy between sustainability and profit. Colby et al. argue that, *"easy problems have mostly been fixed – the remaining obstinate challenges are becoming increasingly expensive to resolve"* (1995, p.135); while Walley and Whitehead state that, *"responding to environmental challenges has always been a costly and complicated proposition"* and go on to suggest that, *"win-win situations [...] are very rare and will likely be overshadowed by the total cost of a company's environmental program."* (1994, p.46). However, even those sceptical about the potential incentives for Sustainable Development are convinced of the need for *"finding smarter and finer trade-offs between business and environmental concerns"* (Walley and Whitehead, 1994, p.47). Many also advocate that these external pressures on business such as environmental regulations stimulate innovation and can in turn provide competitive advantage and additionally, that proactive engagement in sustainable practices lowers the risk of the introduction of new and costly regulations (Porter and Linde, 1995).

It is recognised that companies have a great role to play in addressing Sustainable Development (Porter and Kramer, 2002). But companies simply do not see how to reap the benefits of their efforts, as most strategies benefit stakeholders outside the company implementing them (Porter and Linde, 1995).

While the debate is still active nowadays, environmental regulations are getting stricter and more numerous (figure 1.5). Beyond this regulatory minimum, businesses also face increasing pressure from the public that they have no choice but to address; for example, the 2010 BP oil spill in the Gulf of Mexico (Kinver, 2011) or Apple's EPEAT (Electronic Product Environmental Assessment Tool) rating

controversy in 2012 (BBC, 2012). Then, businesses' sustainability directions vary in many respects, but more and more, companies are thriving marketing and differentiating themselves 'green', with companies like Herman Miller, providing environmental transparency on all their products, subscribing to environmental standards, such as the MBDC (MBDC, 2014). Marks & Spencer also actively promotes their green initiatives (with Plan A), for example setting recycling and reuse schemes and offering consumers transparency reports on the sustainability actions of their operations (Marks & Spencer, 2014).

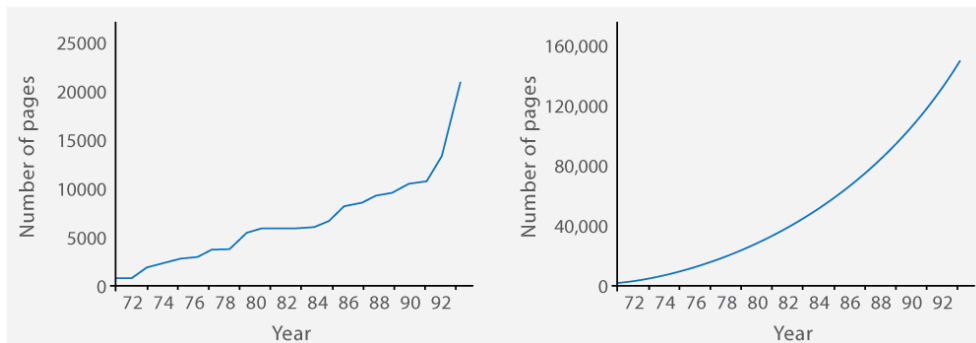


Figure 1.6 – Growth of federal environmental regulation. (a) Legislation by year; (b) cumulative legislation (Handfield et al., 1997) (adapted).

1.4 The Role of Design

This section continues to explore the role of industry and more specifically the role of design in industry, by explaining the role and importance of design in positively affecting environmental impacts and by introducing Eco Design.

“More than 80% of all product-related costs and environmental impacts of a product during its manufacture, use and disposal are determined during the product-planning phase.” (Tischner, 2000, p.9)

Sustainable Production and Sustainable Consumption are two concepts that derive from Sustainable Development. They are linked to the physical activities of governments, companies and society. Sustainable Consumption can be defined as the total amount of resources extracted from the environment, while Sustainable Production can be characterised as the process of transforming these resources to create products, services and waste (Charter and Tischner, 2001). *“Seen this way, all environmental issues are production and consumption issues.”*(Charter and Tischner, 2001, p.32).

Until the late 1980's, the business response to environmental issues was to adopt an 'end-of-pipe' approach (also called 'pollution control'). The aim was to deal with pollution and waste after production. However, with rising environmental awareness, the 1990's saw the development of a 'cleaner production' approach (part of 'pollution prevention') that aimed to prevent the creation of waste in the first place and/or make more efficient use of energy and materials (Roy, 2006). From then, the attention to tackle environmental issues shifted more and more towards the development phase of products and services (Brezet and Van Hemel, 1997). This was also the start of the development of numerous approaches, tools and techniques to tackle Sustainable Development, and more specifically environmental issues (developed in chapter 2).

A main part of the development of products and services is product design. It is the stage that determines the amount of resources products consume during their manufacture, use and end of life, and as a result determines most of their environmental impacts (Tischner, 2000). Baumann et al. (2002) also explain that *“once a product moves from the drawing board to the production line, its environmental attributes are largely fixed”*; which is why Product Design has been seen as a central part to lower the environmental impacts of our production and consumption.

“The ecodesign of products is a crucial factor in the [European] Community strategy on Integrated Product Policy. As a preventive approach, designed to optimise the environmental performance of products, while maintaining their functional qualities, it provides genuine new opportunities for manufacturers,

for consumers and for society as a whole.” (The European Parliament and the European Council, 2005)

As a result, Sustainability is an area for consideration that has grown dramatically in Product Design research since the 1990's (Boks and Stevels, 2007; De Burgos Jiménez and Céspedes Lorente, 2001; Bragd et al., 1998; Karlsson and Luttrupp, 2006).

1.5 Eco Design

Briefly introduced in the previous section, this section defines the discipline of Eco Design, its relationship to Sustainable Development and its ties with the design process.

The arrival and development of environmental concerns in Product Design also marked the development of numerous approaches, tools and techniques. These activities gave birth to the relatively new discipline of Eco Design.

“Ecodesign’ means the integration of environmental aspects into Product Design with the aim of improving the environmental performance of the EuP [Energy-Using Products] throughout its whole life cycle.” (European Parliament and Council of the European Union, 2005)

Eco Design, like Sustainable Development, is an over-arching discipline. It *“considers environmental aspects at all stages of the product development process”* (Brezet and Van Hemel, 1997, p.20), and while it is to be derived from design approaches (Stevels, 2009, p.20), it encompasses the same environmental and whole life cycle thinking that Sustainable Development promotes (see figure 1.7).

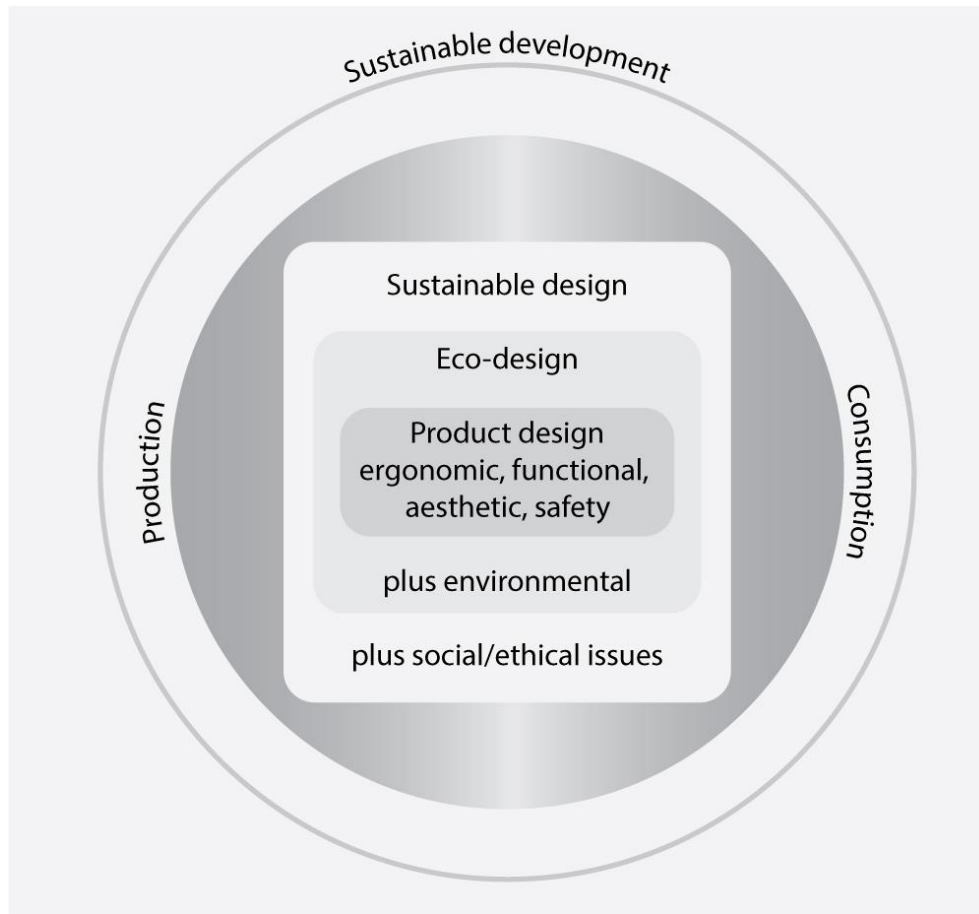


Figure 1.7 – The relationship between Ecodesign, Sustainable Product Design and Sustainable Development (Martin and Charter, 2001, p.120) (adapted).

From the 1990's, following the growth of the Sustainable Development movement, these research activities mainly focused on aiding tools. Those tools (or Eco-Tools) are about: *“finding ways of describing environmental aspects of material selection and generalised ways of dealing with environmental information”* (Baumann et al., 2002). The two main meanings Baumann et al. (2002) outline here are those of *“description”* and of *“dealing with information”*. The first decades of Eco Design research was indeed marked by this search for ways to manage and disseminate a new type of information (i.e.: environmental information). A lot of this new environmental information generated by the designers and researchers had to be gathered, channelled, organised and framed for product designers.

In this sense, Eco Design is the implementation of environmental information in the Product Development process. But it also includes a second step: the use of this information to develop new solutions, lowering environmental

impacts. It is to help manage this two-step process of Eco Design that the aforementioned Eco-Tools were being developed.

From then on, Eco Tools were researched and published to enable designers to implement Eco Design. Doing so, researchers always sought for their integration alongside the Product Design process (Brezet and Van Hemel, 1997, p.37). Many tools were developed to fit with the product development process and to work along existing design tools (Charter and Tischner, 2001; Bovea and Pérez-Belis, 2012).

However, research in Eco Design came to a point where too many tools were being developed (Baumann et al., 2002; Boks and McAloone, 2009). This excess of tools choice created an overload of information; what researchers wanted to solve with those same tools.

1.6 The Product Design Industry

The following section presents an overview of the size and shape of the Product Design industry as well as considerations for investigating it.

Analysing the British Product Design industry is difficult. First, very few comprehensive surveys of the sector have been undertaken. Secondly, it is difficult to segment the design industry and to single out the Product Design industry. There is no standard definition for each segment of the design industry, any definition is subject to a certain level of interpretation or debate, and businesses often do not fit into one specific segment. Then, when analysing the shape and size of the Product Design industry, there is a need to question what the most representative data is. Is it the breakdown of market shares, the spread of small to large businesses, or whether designers work in-house or in design consultancies?

There are three main sources that have endeavoured to present this data. These surveys range in size, have different questions sets and span several years

apart. However, together they form the most comprehensive picture of the Product Design industry available. The first two main sources are surveys from the Design Council (Design Council, 2005; Design Council, 2010). They both analyse the shape and size of the design industry, with some focus on the Product Design segment. Although five years apart, no direct comparison can be made between the results of these studies as they answer different questions. For this reason, both are considered below, providing a fuller picture. The third source of data comes from the Design Week publication, providing a survey for the top 100 design consultancies; thus giving insight on part of the Product Design industry.

Regarding the size and shape, there are several main data sets used to define the Product Design industry:

- the number of Product Design consultancies, freelancers and in-house teams;
- the employee size spread of the Product Design businesses;
- the market share spread of the Product Design businesses

Again, these numbers need to be considered carefully since different studies include slightly different categorisations of the population.

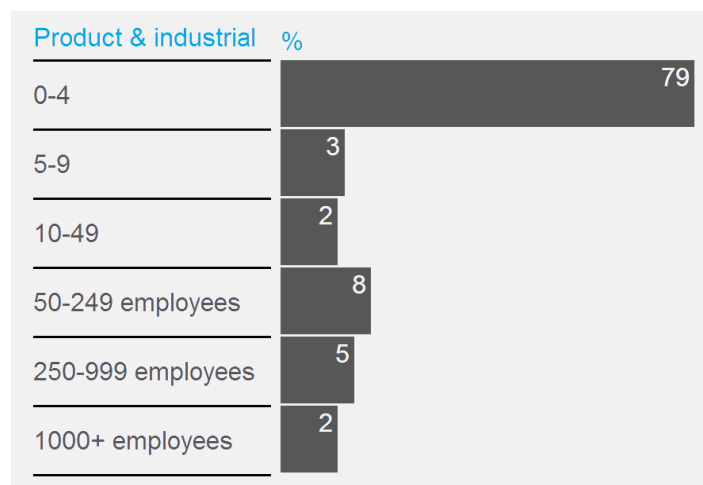


Figure 1.8 – The size of Product Design businesses (Design Council, 2005).

In terms of employee numbers, it is clear from figure 1.6 above, that the industry is largely made of very small businesses; with over 80% of businesses with less than 10 employees.

In terms of the spread between Product Design consultancies, freelancers and in-house teams, there seems to be as many design consultancies and freelancers combined as in-house design teams (see figure 1.7 below).

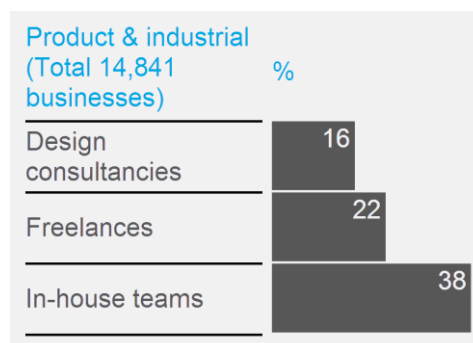


Figure 1.9 – Design Team Types of Product Design businesses (Design Council, 2005).

In terms of market shares, the Design Council's survey (2005) explains that "77% of design businesses have a turnover of less than £100,000 a year", which aligns with the percentage of small businesses. However, it seems that a very small number of businesses take up a large amount of the market share (as seen in the figure 1.8).

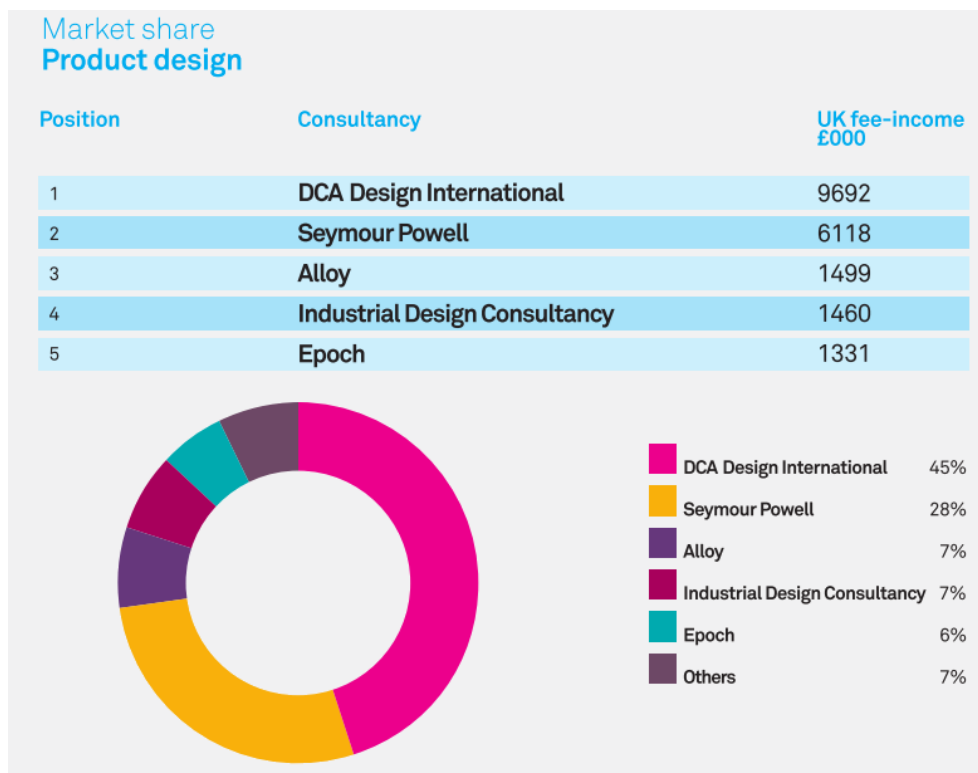


Figure 1.10 – Product Design market share for Product Design consultancies (Relph-Knight 2011, p.39).

This table shows that DCA Design International accounts for 45% of the market share of Product Design consultancies, and that in total, the three biggest businesses in this category account for 80% of the market share. This highlights the prominent role of a few big players in terms of the bulk amount of Product Design work being done in the industry. In terms of the number of businesses, it is clear that the Product Design industry is fragmented over a vast majority of small businesses. In-house Design teams are more difficult to get numbers from, as they are an integrated part of larger businesses.

It could be argued that investigating the work of these top design consultancies would result in a coverage of the vast majority of the environmental impacts influenced by design consultancies as a whole. However, even if there is a correlation between the market share of a design consultancy and the weight of the environmental impacts of its design outputs; this is not to say there is a correlation between market shares and the Eco Design performance of a company or its opportunity to reduce the environmental impacts. This may be subject to the field of work, e.g.: medical, automotive or retail. Therefore, it is as much the

investigation across the bulk amount of British design work (market share); as the diversity of Eco Design activities and business settings (large to small design consultancies and in-house design teams) that is key to this research.

Therefore, in terms of case selection for this research, it seems that diversity is key. On the one hand, large design consultancies and in-house design teams should provide insight on the bulk of the design work being undertaken in the UK. On the other hand, small businesses should help explore what drivers and barriers are faced by a large proportion of the design profession as well as identifying the different types of challenges small businesses face compared to larger ones.

1.7 Areas of Research and the Need for Empirical Research on the Practices of Eco Design

This section introduces the main areas of research in Eco Design, as well as the gaps in research most mentioned in the literature, including those that are investigated in this research.

Since the 2000's, researchers have been voicing the need for empirical research on the practices of Eco Design (Baumann et al., 2002; Boks, 2006). However, there still remains today a clear lack of empirical knowledge in this area. Most academics have preferred to continue to propose new tools, frameworks and guidelines with a new angle - usually wider, for example including social sustainability aspects into Eco Design. Of those, no leading tool has emerged. And although one could argue that the International Organization for Standardization's standard ISO 14006 ('Guidelines for incorporating ecodesign') is a step forward towards a certain international unity; the standard remains in its infancy (dating from 2011) and is in competition with many other aspiring standards. Overall, there appears to be a limited awareness of these tools, and identifying this will be part of

the research investigation. In the same way that new terms for the same Eco Design concept are introduced every so often, researchers seem more interested to introduce new tools than evaluating or building up on existing ones. Karlsson and Luttrupp (2006, p.1291) support this idea and argue: *“The tools in EcoDesign are not as important as specification and goal setting in early product development phases. How to organize product development is crucial in order to reach higher degrees of sustainability”*. Research also concentrates on case studies and success stories to illustrate the potential of Eco Design and Eco Design tools. However, these really do not produce enough variety of data to enable any generalisations.

In all, the focus of current research revolves around organising and framing ‘information packages’ for potential use by product designers; providing at best, success stories for approval. The discipline is in need of a clearer understanding of what has actually been taken on by Product Designers in regards to Eco Design workflows (if at all), and to investigate the drivers and barriers currently faced. Very little research has been done on this subject. The need for this research is further developed during chapters 2 and 3 and then reviewed at the end of chapter 3.

1.8 Research Aim, Objectives and Contributions

The previous sections provided a background to this research, Sustainable Development, Product Design and Eco Design, but also introduced the need for research on the practices of Eco Design. In turn, this section puts forward the aim, objectives and contributions that will shape this research.

As discussed in the previous sections, Eco Design research focuses mostly on the development of Eco Tools for industry. However, there is little empirical research on the implementation and testing of these tools (Baumann et al., 2002). Little has also been empirically explored regarding the prerequisite needs of the Product Design industry to successfully implement Eco Design processes (Lindahl,

2006). Therefore, the **aim** of this research is **to review the current level and type of Eco Design in the British Product Design industry and to identify recurrent themes helping or hindering implementation**. First, the review of Eco Design thinking and implementation will provide research with a timely picture of the Eco Design landscape and help direct research with a better understanding of industry practices. Secondly, the identification of themes (drivers and barriers) in Eco Design will support an understanding of the strengths and shortfalls of the current Eco Design processes and tools present across the industry and to help formulate better solutions accordingly.

Research Question 1: What is the current state of the art in Eco Design implementation?

The first rationale for undertaking this research is the lack of empirical knowledge (mentioned in the previous section) regarding the implementation and development of Eco Design in the Product Design industry. Many academics have focused their research on the development of Eco Tools but lately, there has been serious questioning as to the value of more tools, and as to the actual relevance, rate and depth of implementation of these tools. The research will address what appears to be a clear shortfall of empirical data on the state of implementation of Eco Design.

Research Question 2: What are the methods used to implement Eco Design?

The second rationale for undertaking this research is closely linked and derives from the first. While many Eco Tools have been developed, there seems to be a clear lack of knowledge on what Eco Tools or other Eco Design implementation methods Product Designers are using, if any. The research will identify what methods of Eco Design Implementation (developed by academia or industry) Product Designers are practicing.

Research Question 3: What factors are affecting Eco Design implementation?

The third rationale for undertaking this research regards the general factors that may enable or hinder Eco Design implementation in the Product Development process. Academic research points at the importance of several factors, especially

of organisational management, for the success of Eco Design, while not offering extensive empirical studies to convey this argument. Consequently, a final aim of this research is to explore and identify the existence and importance of these factors on the implementation of Eco Design and Eco Tools.

In order to fulfil its aim, the research will focus on achieving the following objectives:

Objective 1 - To review the relevant literature on Eco Design approaches and tools as well as implementation and success factors;

Objective 2 - To undertake a pilot study to provide insights and directions for the research activities and its methodology;

Objective 3 - To explore the current level and type of Eco Design and recurrent themes helping or hindering implementation;

Objective 4 - To provide a sufficient breadth of data to validate findings across the British Product Design industry;

Objective 5 - To provide a critical overview of Eco Design implementation as well as recommendations for the industry.

Providing an in-depth and timely picture of Eco Design in the UK will make substantive contributions to the gaps in Eco Design literature identified above and in chapter 2. Firstly, the research will provide new knowledge, describing the level of the implementation of Eco Design in the British Product Design industry. Secondly, the research will investigate and present a summary of the key attributes of Eco Design practice. Thirdly, the research will provide a timely and novel understanding of the factors affecting adoption and implementation.

This thesis is structured in nine chapters. Chapter 1, the introduction; chapter 2, revealing the relevant literature; chapter 3 on methodology; chapters 4, 5 and 6 on the research stages; chapter 7 on findings; and chapter 8 providing a conclusion to both the research and the thesis. This structure is presented in more detail below in table 1.1 and figure 1.9.

1.9 Thesis and Research Structure

Ch. 1	Introduction The first chapter presents the context of the research, defines the specific research area, explains the rationales for undertaking the research and presents the aim and objectives of the research.	Aim: To set the scene for the research.
Ch. 2	Literature Review This chapter first introduces Eco Design and its developments along the last twenty years. It then presents a review of the literature on the implementations of Eco-Design in industry and communicates insights showing the gaps in knowledge regarding implementation in industry.	Aim: To provide an understanding of the field and basis for this research. To identify research methods, to help devise this research's methodology.
Ch. 3	Methodology With insight from related academic research presented in the previous chapter, this chapter provides an initial outline of the research design for this research and the rationales for the decisions made.	Aim: To establish the adequate methods for collecting and analysis the data for this research.
Ch. 4	Pilot Study Chapter four provides a report of the insights gathered during an initial pilot study of British design teams, as well as the consequent methodological adjustment that resulted from the experience and knowledge gathered.	Aim: To help understand the research context and adjust the methodology accordingly.
Ch. 5	Explorative Research Stage Chapter five presents the first of the two main research stages. It presents an account of the explorative research activities and the thematic analysis conducted on the study of four design project cases.	Aim: To explore the level of Eco Design implementation and tease recurrent themes.
Ch. 6	Corroborating Research Stage Chapter six present the second main research stage. It presents the findings from the set of case study which provided corroboration and confirmation of findings through the study of eight company cases.	Aim: To confirm, modify and validate the existence of themes and their findings.
Ch. 7	Findings This chapter presents and discusses the findings on the found themes and the knowledge gained during the research. It also discusses the levels of reliability, validity and generalizability of the results.	Aim: To present and discuss the findings of this research.
Ch. 8	Conclusions This last chapter provides hinsight on the journey, contributions and implications of the research. It ends with reccomendations for further research in the area.	Aim: To provide a conclusion to this research and avenues for further research in the area.

Table 1.1 – The Thesis Structure.

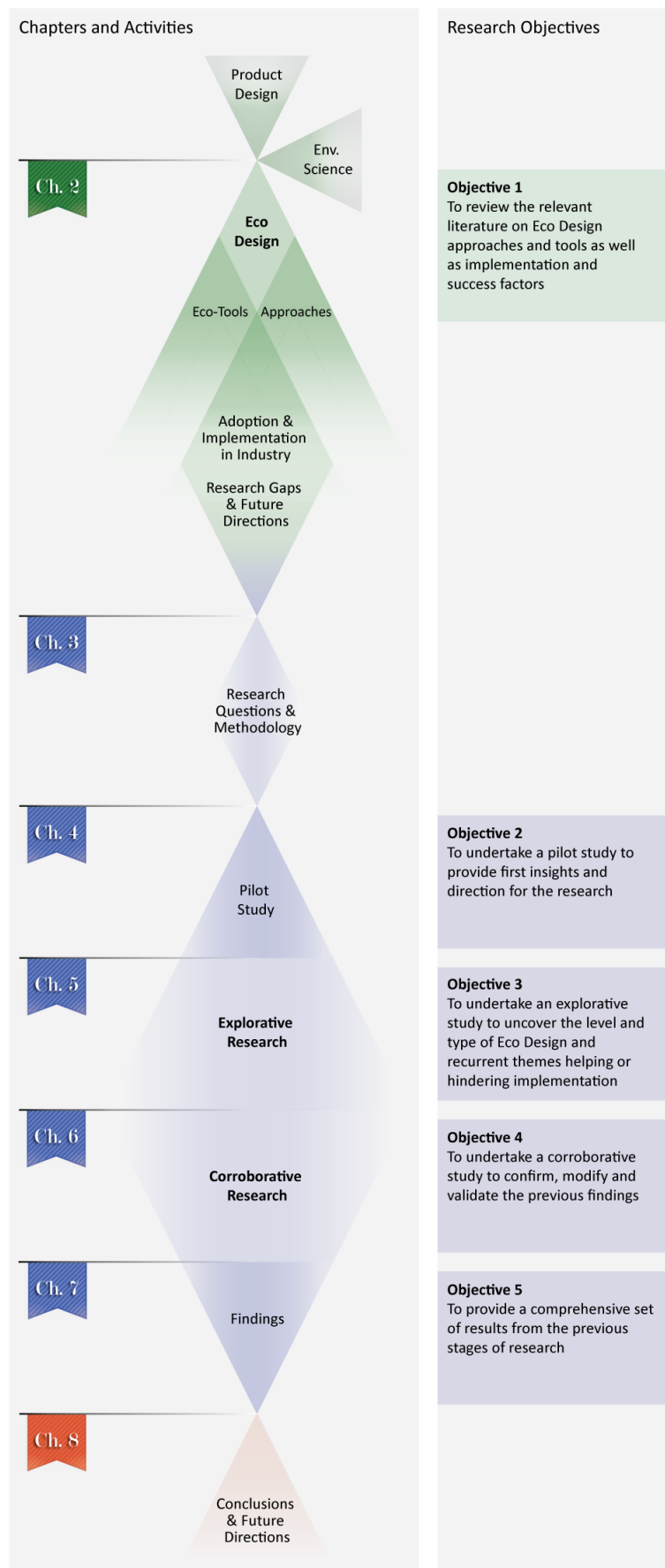


Figure 1.11 – The Research Structure.

Chapter 2 - Literature Review

This chapter presents the literature surrounding Eco Design. It first presents a definition and history of the development of the field, exploring its roots in Environmental Sciences and Product Design. It then provides an understanding of the Eco Design process and Eco Tools and their origins. The chapter finally reviews the different studies on the implementation of Eco Design and Eco-Tools in industry, with a focus on the factors affecting implementation.

2.1 The Search for Literature in Eco Design

This opening section provides an overview of the literature search process undertaken during this research and how it was shaped by the interdisciplinary nature of the Eco Design discipline.

Eco Design is a concept that has had great repercussions in both industry and academia, specifically during the last 20 years (Boks and Stevels, 2007). Researchers from around the world and across many disciplines have looked, from their own perspective, at Eco Design due to the interdisciplinarity of the subject, connected to environmental issues and product development research. As mentioned in the introduction chapter, the terminology of Eco Design has developed in a way that has duplicated terms for the same meaning. This has blurred both the limits of what defines the concept and of what separates connected disciplines. For example, looking at ‘green product development’ could mean different things whether the research is conducted in supply chain

management or Product Design. Additionally, the term is itself not consistently used in the same way within each discipline; as for example in Huang and Wu (2010) with a Product Design perspective or Albino et al. (2009) with a business perspective. Another element worth pointing out is that while lowering the environmental impacts of a product can be a matter of both Supply Chain Management (with Sustainable Supply Chain Management) and Product Design (with Eco Design), their activities are often only approached from their own perspective. This research, concerned with Product Development from a Product Design point of view, presents in this chapter the viewpoints and arguments of both the Product Design and other related disciplines. The chapter also outlines the shortfalls relating to the non-systemic approaches present in literature.

This array of terminology surrounding Eco Design makes it difficult to search for relevant content (Brones and Monteiro De Carvalho, 2014). Gathering knowledge in this interdisciplinary area of research, covering several disciplines, involves a great breadth of searching and reading, therefore raising concerns relating to the limits and boundaries imposed on the study. Initially, a scan of the literature helped to hint at research directions. Using online databases, the search first employed terms gathered from the research proposal, offering a multitude of results that were often not directly relevant. For example, using 'green design' as a search term brings many results that are unrelated to either product development or even environmental concerns; showing for example, results on sustainable architecture or waste management policies.

Two complementary and iterative processes of finding relevant literature were therefore developed to add rigour to the search. The first process focused on finding new literature through more relevant search terms (see figure 2.1). An initial list of terms was used to search for literature through online databases and libraries. The results of this activity provided new relevant literature which in turn provided new search terms; these were then used in the following iteration to find more relevant literature, and search terms.

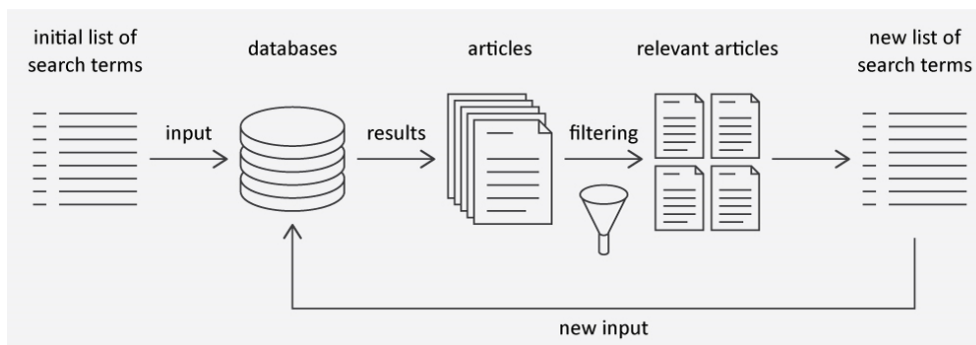


Figure 2.1 – Iterative process to find new literature using new search terms (original work).

The second iterative process focused on the references and cited-by lists of each piece of literature (see figure 2.2). For each piece of literature, both its references and its citations were searched using online databases.

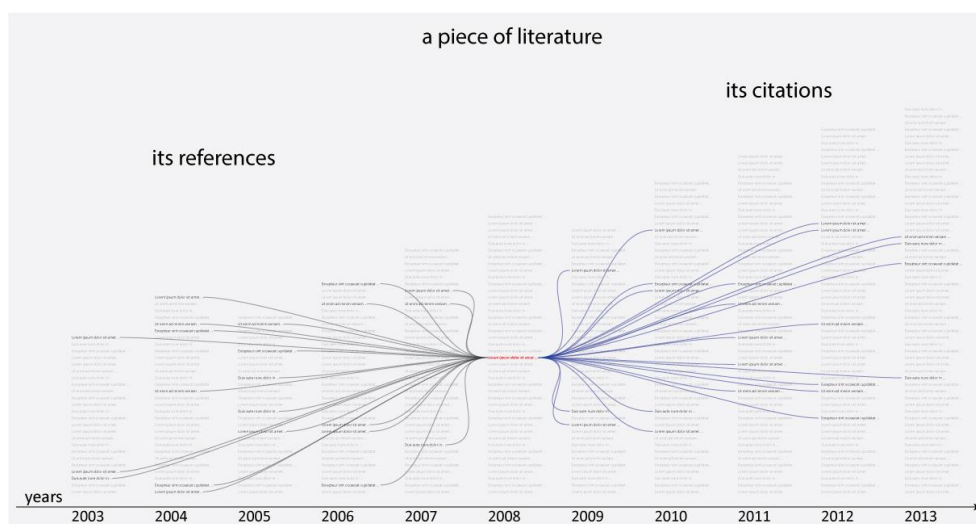


Figure 2.2 – The relationship between a piece of literature, its references and citations (original work).

During the first iterations of these two processes, no restrictions were imposed on journal titles or years of publications. As the search continued, 'key articles' (referenced in the following text) and 'key journals' (such as the journal of Cleaner Production) emerged; by coming up as results recurrently, by being mentioned in references or cited by lists. Key journals were then searched independently of search terms to find new relevant content and possibly new

search terms. This helped to see if any niche areas of research had been missed in the search, but had been published in the relevant journals.

Both iterative methods helped find the relevant literature and lexicon for this research. The search moved towards a state of saturation; where fewer and fewer new articles appeared and no more relevant articles were found (see figure 2.3). This process validated the relevance of the results and the completeness of the search in a more systematic way.

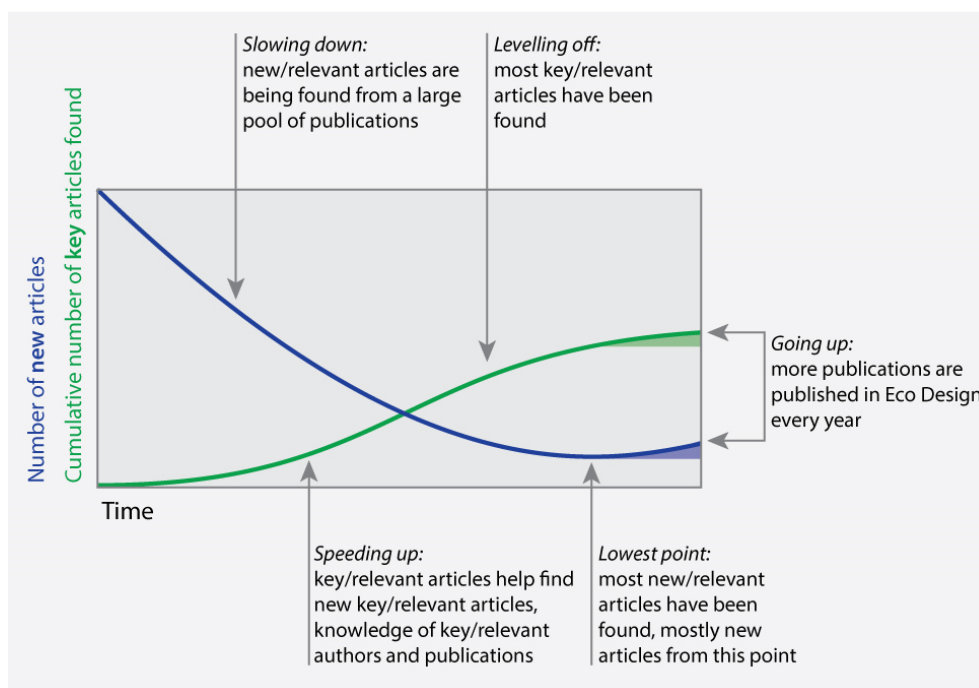


Figure 2.3 – Emergence over time of new and key articles (original work).

2.2 The Definition of Eco Design

This section reviews the development of the terminology in Eco Design from the early 1990s and the efforts of academia to define the emerging field.

An array of different terms has emerged defining this concept that integrates environmental concerns as one of many aspects in Product Design. All of these terms (and their definitions) have evolved in the past 15 years, especially those of Eco Design and Sustainable Design. For the whole of that time, *“The meaning of ‘environment’ or ‘greening’ is ambiguous and may imply different things to professionals in various fields.”* (Gupta, 1995, p.36).

Green Design, Ecological Design, Environmentally Sensitive Design, Eco Design, Design for Environment (DfE), Environmentally Responsible Design, Sustainable Design, etc. are terms that have been created by different disciplines, in different countries and across years of publication. Many of these terms, such as Environmentally Conscious Design and Environmentally Responsible Design, are seen as interchangeable or synonymous (Boks and Stevels, 2007; Albino et al., 2009; Nuij, 2002). The rapid increase in research in this emerging field (see figure 1.3) may explain why so many terms have been created, with the same or similar meaning. Another development in this terminology relates to the details of how terms are spelt, across years of publication and academic disciplines. The different spellings of Eco Design (e.g.: Ecodesign, ecodesign and Eco-Design), not to be confused with Ecological Design, is a prime example of this phenomenon. This thesis uses ‘Eco Design’ but ensures to preserve the spellings used by sources when quoting. Confusion is easy for the novice and the public in general; and one hopes this research contributes to some clarification and consensus. This section presents definitions of the terms, an understanding of how they have evolved, and a definition of Eco Design as used in this research.

In 1996, Emma Dewberry wrote her PhD Thesis entitled: *“Ecodesign - Present Attitudes and Future Directions: Studies of UK Company and Design Consultancy Practice”*. Her research focused on understanding the attitudes and directions of Eco Design within the design industry at a time of infancy for the

discipline (Charter and Chick, 1997). Because the aim of the present research is closely linked to that of Dewberry's work, this literature review chapter extensively references her thesis that provides a base for understanding Eco Design in Product Design over the subsequent years. Dewberry's work, and especially her literature review, shows the state of infancy of the field at the time. She grounds the Eco Design research field in 60's and 70's literature in the work of Papanek (and Bonseipe) that explores the lack of environmental awareness of our unsustainable mass consumption patterns (p.2). Others may ground the work deeper in the 19th century old London, with its environmental problems linked to a rise in population and to the birth of the industrial age (Williamson, 2002). However, the emergence of the academic field linking environmental concerns to industrial production can be placed around the end of the 1980's (as discussed in Chapter 1); which is why Dewberry references hardly any environmental related sources prior to 1987. This places her work at the beginning of the development of Eco Design as a research field.

Dewberry segments the field into three dimensions: conceptual (*"we have progressed to viewing the subject in a much wider context"* p.38), time (*"The language in the field of Environmentally Responsible Design has evolved rapidly since the late 1980's"* p.38) and location (*"in the USA, the generic term Design for Environment (DFE), is very popular. [...] In Australia the terms 'Ecodesign' and 'Eco-redesign' are commonly referred to [...] whereas in Holland, Germany, Italy and the UK a mixture of all these terms exist."* p.38). Van Hemel (1998) also reports this phenomenon on how the terminology varies according to the country of publication, and reinforces by stating how (already in 1998) *"these verbal shadings tend to cause confusion"* (Van Hemel, 1998, p.17-18).

Today, it is interesting to create parallels with Dewberry's review and her research to understand better the developments of the field. This is done throughout this chapter by first looking at 1996's take on 'What is Eco Design?' in which Dewberry defines Eco Design and related terms. This is a usual practice amongst thesis writers (e.g.: Dewberry, 1996; Van Hemel, 1998; O'Hare, 2010) to help set their definitions of the field of research investigated ahead, and the motive is no different here. Using contemporary sources, Dewberry pays particular attention to defining Green Design, Eco Design and Sustainable Design; allowing

her to define her field of research (Eco Design) but also to define it in context to similar terms, highlighting their differences with Eco Design.

Green Design	<i>“...focuses on one or two particular areas of environmental impact such as energy efficiency or material recycling...” (p.28)</i>
Eco Design	<i>“...here the design process attempts to reduce and balance the environmental impacts of a product at each stage of its life cycle, from raw materials through to end of life disposal.” “The key point is that the product must not go beyond the current market acceptance of ‘newness’ or be too ‘radical’...” (p.29)</i>
Sustainable Design	<i>“...aims to satisfy design criteria within the complex system of sustainable development...” “systems based” “...imagining something that does not exist until that moment” (p.30)</i>

Table 2.1 – Dewberry’s (1996) definition of Green Design, Eco Design and Sustainable Design.

A popular categorisation is presented by Brezet and Van Hemel in 1997 where Design for Environment is seen as a concept nesting Green Design, Ecodesign, Sustainable Design and Sustainable Innovation. The author represents this through a graph (figure 2.6) of eco-efficiency improvement against time to show how the concepts inter-relate. The main trait of this graph, regardless of terminology, is the idea that eco-efficiency (level of Eco Design implementation and success) increases over time. However, the underlying idea that these concepts somehow come one after another (over time only) and that they are linked in this rigid way is not something that seems to resonate much with later publications. As Dewberry explains (1996, p.28), all these terms relate to reducing the environmental impact of a design. However, trying to develop term hierarchies or categorisations does not change that their main purpose is the same.

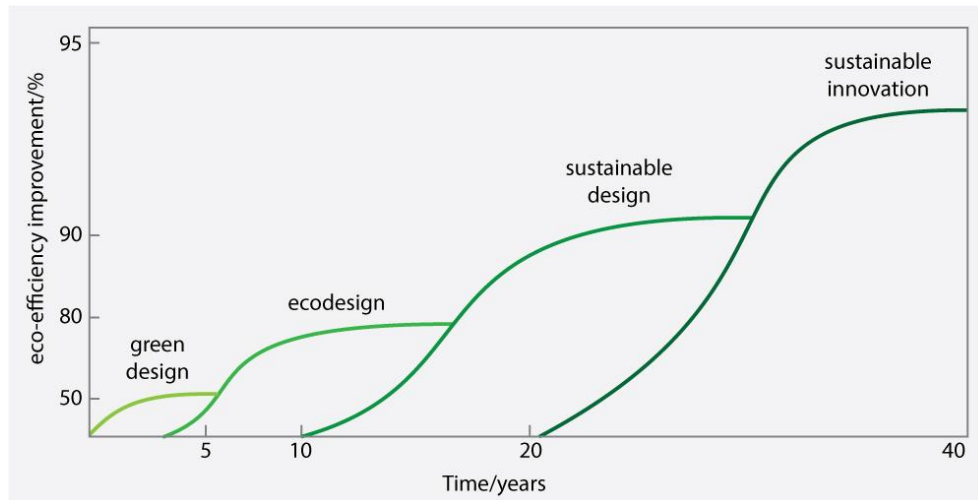


Figure 2.4 – Eco efficiency curves (Brezet, 1997, p.22) (adapted).

O’Hare (2010) also contextualises his field of research by defining these terms:

“DfE [Design for Environment] integrates environmental considerations into Product Design but focuses on one phase of the product life cycle; eco-design broadens this to consider the entire product life cycle; eco-innovation extends eco-design into the early stages of innovation; ECD [Environmentally Conscious Design] is an umbrella term for DfE, eco-design and eco-innovation; and Sustainable Design is any form of ECD that considers social and economic aspects of sustainability as well as the environmental aspects.” (O’Hare, 2010, p.15-16)

While his definition of Sustainable Design integrates the concept of the Triple Bottom Line and fits with current adoptions of the term, his definition of Design for Environment brings confusion by differentiating it to Eco Design. Indeed, contrary to O’Hare, most academics, including Dewberry (1996) and Charter and Tischner (2001) do not differentiate the meanings of Design for Environment and Eco Design. They show them as interchangeable terms. The difference is actually mostly due to the locations where each is used: Design for Environment in the USA, Eco Design in Europe and Australia (Dewberry, 1996; Baumann et al., 2002). Eco-Innovation (the main term used in his research) is itself sparsely used across the field – so is Environmentally Conscious Design in relation to the other terms cited and the claim relating it as an *“umbrella term”* is not widely found in literature.

Another example of such confusion in regards to terminology appears in Charter and Tischner (2001). The authors first define both concepts at once, without differentiation: *“Ecodesign and design for environment (DfE) are terms for strategies that aim to integrate environmental considerations into Product Design and development.”* (p.121). Later on, in a chapter titled *“Measuring Sustainability in Ecodesign”*, it seems Sustainability and Eco Design are almost interchangeable or at least not following prior definitions. Here, the particular confusion in terminology may be explained knowing the chapter is written by a different author, Fiksel. In Chapter 14, *“Tools for Ecodesign and Sustainable Product Design”*, Tischner redefines Eco Design as: *“environmentally conscious product development and design, or design for environment.”* (p.263). Eco Design and Design for Environment are clearly stated as interchangeable but the confusion reoccurs when the author presents a sub-section on the *“key aspects of Sustainable Design”* but changes to use the term *“Ecodesign”* within the section itself.

Although this very informative resource is the work of several authors, most of whom are leaders in the field; it seems this cannot account for all the terminology confusion that is present since the confusion appears within chapters too. In all, this provides a good representation of the field as a whole (in regards to terminology), where, although there exists good explanations (as with the figure below); there is no real consensus amongst academics, nor consistency in the terms used.

Overall, in some form of unintentional consensus, two main terms have emerged: Eco Design and Sustainable Design. Charter and Tischner’s influential text on the subject (2001) provides us with definitions for both terms; which they summarise with the figure below:

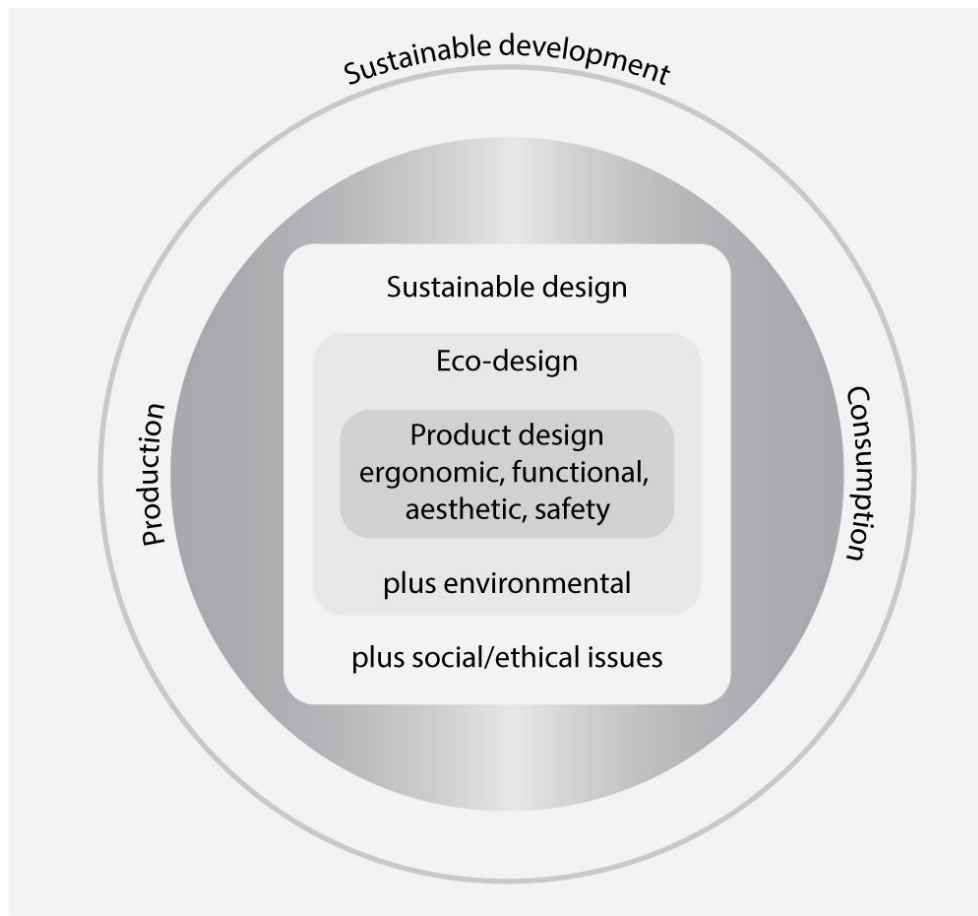


Figure 2.5 – The relationship between the different disciplines of Product Design, Eco Design, Sustainable Product Design and Sustainable Development (adapted from Martin and Charter, 2001, p.120).

This figure presents a visual, simple yet effective representation of Eco Design in relation to both Product Design and Sustainable Development. Eco Design integrates standard Product Design aspects such as “*economic, functional, aesthetic, safety*” aspects; and surrounds those with a ‘layer’ of environmental concern. However, it does not aim to deal with the social aspects of Sustainable Development, which the Sustainable Design ‘layer’ does.

Baumann (2002), on the basis of an extensive literature review of the field, confirms the evolution of those synonym terms:

“The original term, Green Design, has been replaced by Ecological Design, Environmentally Sound or Environmentally Sensitive Design or Ecodesign, DfE, Design for the Environment, and Environmentally Responsible Design”;

and indicates that the main reason for the development Eco Design and Sustainable Design is:

“The transition from ‘green’ to ‘eco’ to ‘sustainable’ design represents a broadening of scope in theory and practice and also to some extent an increasingly critical perspective on ecology and design. The changing terminology represents a different time perspective and gives a framework of how the subject has emerged.”
(2002, Baumann, p.413)

To conclude this section, the table below show the evolution of the concept of Eco Design (and its synonymous concept, Design for Environment) across three decades.

	Design for Environment	Eco Design
1990's	<i>“...systematic consideration of design performance with respect to environmental, health, and safety objectives over the full product and process life cycle.”</i> (Fiksel, 1996)	<i>“...design which addresses all environmental impacts of a product throughout the complete life cycle of the product, without unduly compromising other criteria like function, quality, cost and appearance”</i> (Dewberry and Goggin, 1995)
2000's	<i>“Design for Environment (DfE) optimizes the relationship and interaction of the economic system and the environmental system, and strives to produce a sustainable development and enterprise integration.”</i> (Sun et al., 2003, p.59-60)	<i>“Ecodesign means the integration of environmental aspects into Product Design with the aim of improving the environmental performance of the EuP [Energy-using Products] throughout its whole life cycle”</i> (European Parliament, 2005, p.29)
2010's	<i>“Design for environment (DfE) is a practice by which environmental considerations are integrated into product and process engineering design procedures. DfE practices are meant to develop environmentally compatible products and processes while maintaining product, price, performance, and quality standards”</i> (Ramani et al., 2010, p.2)	<i>“Ecodesign is based on a life-cycle approach: the environmental impact of the product is analysed throughout its life-cycle, from cradle to grave.”</i> (European Commission, 2014) <i>“Integration of environmental aspects into Product Design and development, with the aim of reducing adverse environmental impacts throughout a product's life cycle”</i> (ISO 14006, 2011, p.2)

Table 2.2 – The emergence of the concepts: Design for Environment and Eco Design, across three decades.

As discussed in Chapter 1, the present research is interested in the introduction of environmental concern to Product Design: Eco Design. This research defines Eco Design as: ***The integration into product and engineering design of practices for lowering the environmental impact of products across their life cycle whilst not hindering design brief criteria such as function, price, performance, and quality.*** From this definition can be drawn out the main attributes of Eco Design. Eco Design should not compromise the key objectives of Product Design: function, performance, quality and value (Simon et al., 1998). Eco Design and its process should help reduce environmental impacts of the products across their life cycle. Eco Design should finally be integrated within other product development processes, and specifically Product Design.

This research, after establishing Eco Design as the term most used in Europe, by product designers, the design council and the European Union, uses it and the preceding definition for the remainder of this thesis. The research will however not dismiss data on Sustainable Design approaches as these are seen to be including Eco Design. Following this definition of the research area, the following section describes the Eco Design process.

2.3 The Eco Design process

As defined in the previous section, Eco Design is rooted in both Environmental Sciences and Product Design. Therefore, and in order to understand the Eco Design process and how it sits within Product Design, this section first presents an overview to the relevant Environmental Sciences concepts and then the Product Design process. This contextualization of Eco Design then offers a way to present the Eco Design process itself.

Life Cycle Thinking and Life Cycle Assessment

“An ecodesign process should be based on the concept of Life Cycle Thinking, which requires consideration during the design and development process of the significant environmental aspects throughout their life cycle stages.”
ISO14006, p.19, 2012

This sub-section presents an overview of both Life Cycle Thinking and Life Cycle Assessment. Both are essential components in Environmental Sciences. Life Cycle Thinking is a fundamental concept and Life Cycle Analysis is a complex tool operationalising Life Cycle Thinking. The two concepts work as a whole, rather than in any hierarchy or order, and both feed into the Eco Design process. Life Cycle Thinking takes a holistic outlook on (human) production (Tischner, 2000). It sees the life of products as part of a flow of materials and energy from raw materials to disposal, where energy is present at every stage. The approaches to Life Cycle Thinking segments this flow into phases (such as raw material extraction and disposal). While the different approaches may segment the life cycle phases in slightly different ways, the overall approaches can be seen as follows: materials extraction and processing (+transport), manufacture (+transport), trade (+transport), use (+transport), end of life (+transport) (ISO 14062, 2002; figure 2.6).

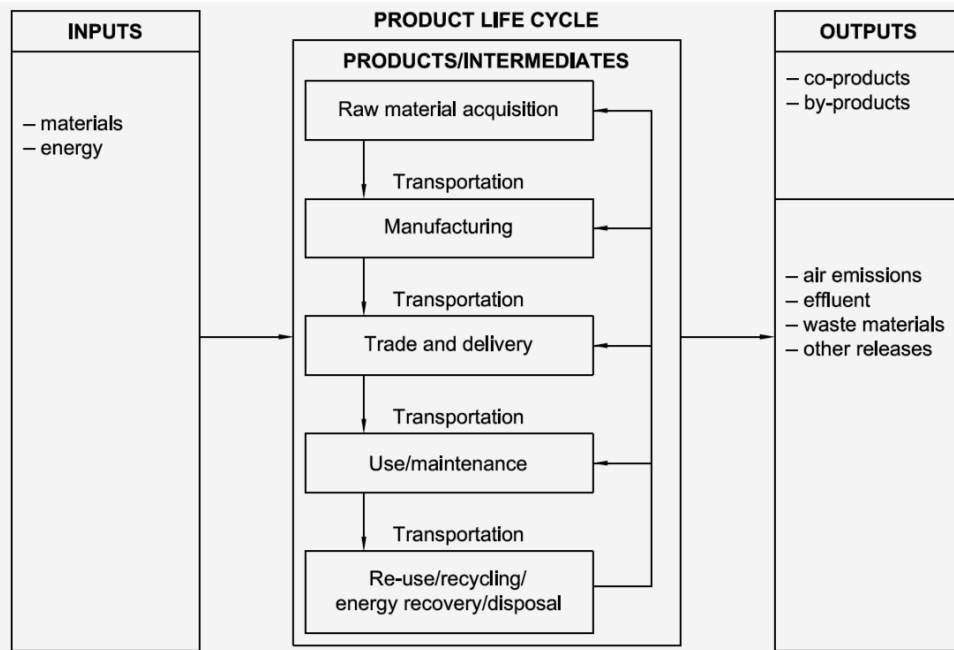


Figure 2.6 – Life cycle phases and relationships to its inputs and outputs. Adapted from ISO 14062 (2002, p.8).

For each of these steps, there are inputs of materials and energy, and outputs of co-products, by-products and releases of waste. Life Cycle Thinking is interested in the environmental impacts, within each of these phases, directly resulting from the stress induced by the use (inputs) and release (outputs) of resources.

There is also a very similar concept to Life Cycle Thinking that views outputs from production and inputs from nature as interlinked. The concept, called 'Cradle to Cradle', redirects the linear Life Cycle Thinking concept into a closed cycle one (McDonough and Braungart, 2010). Wastes from the disposal phase are used as resources for the raw material acquisition phase and no material escapes the loop (figure 2.7). This concept represents a cycle occurring in nature on long timespans (up to geological time-scales). In terms of human consumption, it is an aspiration rather than a reality.

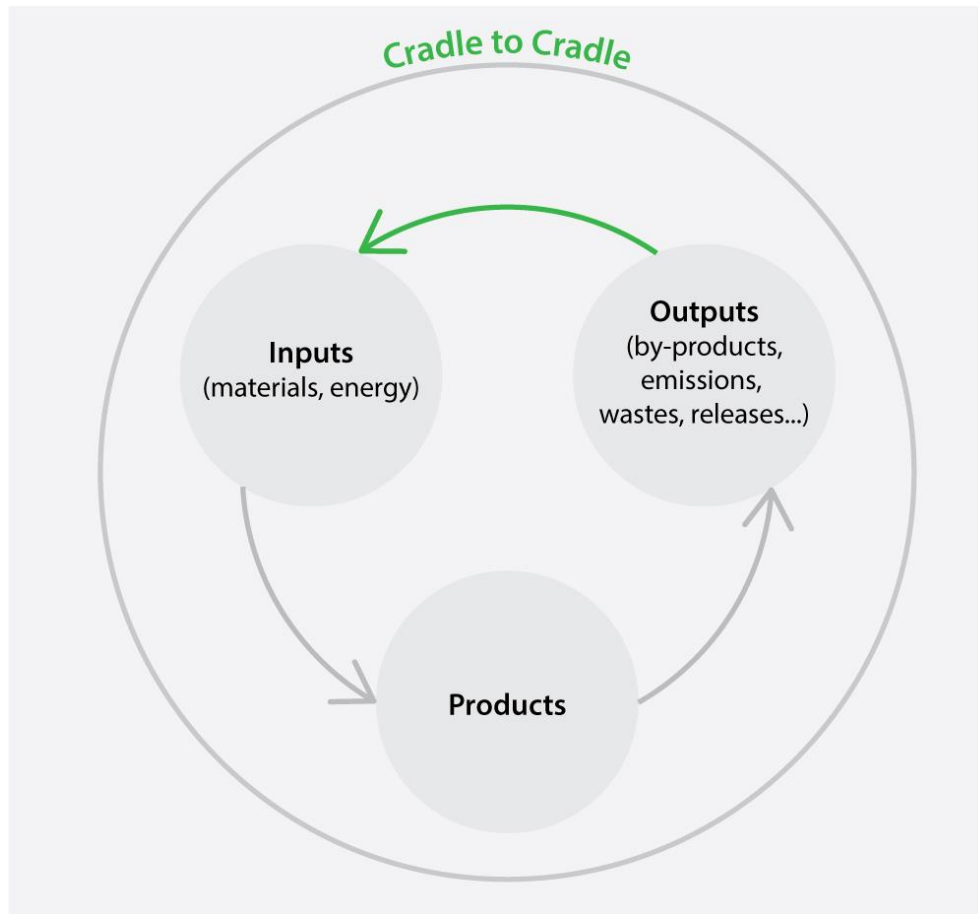


Figure 2.7 – Cradle to Cradle - Life cycle phases and relationships to its inputs and outputs (original work).

While Life Cycle Thinking offers a map of the different product life phases and environmental stress areas, Life Cycle Assessment investigates each of those phases and areas to identify the amount of environmental stress each poses. Life Cycle Assessment is a technique which consists of four main parts (Figure 2.8). ‘Goal and Scope Definition’ helps contain and focus the assessment within specific boundaries, but also to set achievable goals and objectives to the exercise. ‘Inventory Analysis’ goes through each phase of the product life cycle to identify all inputs and outputs. ‘Impact Assessment’ is where each of the identified inputs and outputs are assessed in terms of environmental impact. This includes the weighting of each impact in terms of specific metrics, such as energy, gas emissions and toxicity. ‘Interpretation’ is not per se the final stage, since it runs throughout the other stages. The stage identifies and evaluates the significance of results from the other stages and provides with conclusions, limitations and recommendations on

the study. The results from the Life Cycle Assessment exercise can then inform the Product Design process.

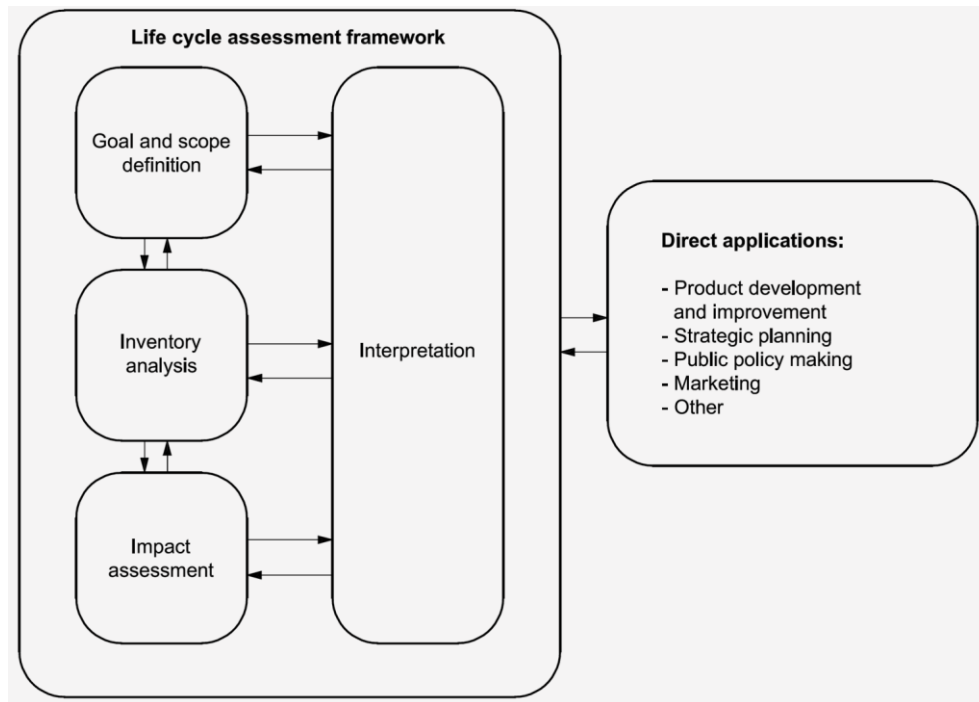


Figure 2.8 – Stages of an LCA, ISO 14040 (2006, p.8).

The Product Design Process

“The existing eco-design literature is largely silent on design theory, which is potentially a critical oversight.” (Deutz et al., 2013)

The reason why Product Design is central to lowering environmental impacts is because it is at the Product Design stage of overall product developments that materials, processes and energy specifications are set. Using a well-known quote within the field: *“More than 80% of all product-related costs and environmental impacts of a product during its manufacture, use and disposal are determined during the product planning phase”* (Tischner, 2000, p.9). Therefore, to understand the structure of Eco Design and the context in which it is implemented (Product Design), this section provides a description of the Product Design process and its variants.

The Product Design process has been subject to decades of defining research and to a multitude of innovative new ways of being approached (Design Council, 2007). However, there is a general consensus regarding a ‘standard design process’ that is well documented in literature (see figure 2.9). Apart from certain dissimilarities regarding the segmentation of the boundaries; the phases of the process remain similar. Pugh (1990) emphasises the design process not as a one way, longitudinal process; but an iterative process which requires back and forth interactions between the different phases and iterations within each stage. These definitions and phases of the design process remain the ones in use today in the UK, championed by the Design Council and forming the basis for the British Design Management Systems standard (BS 7000).

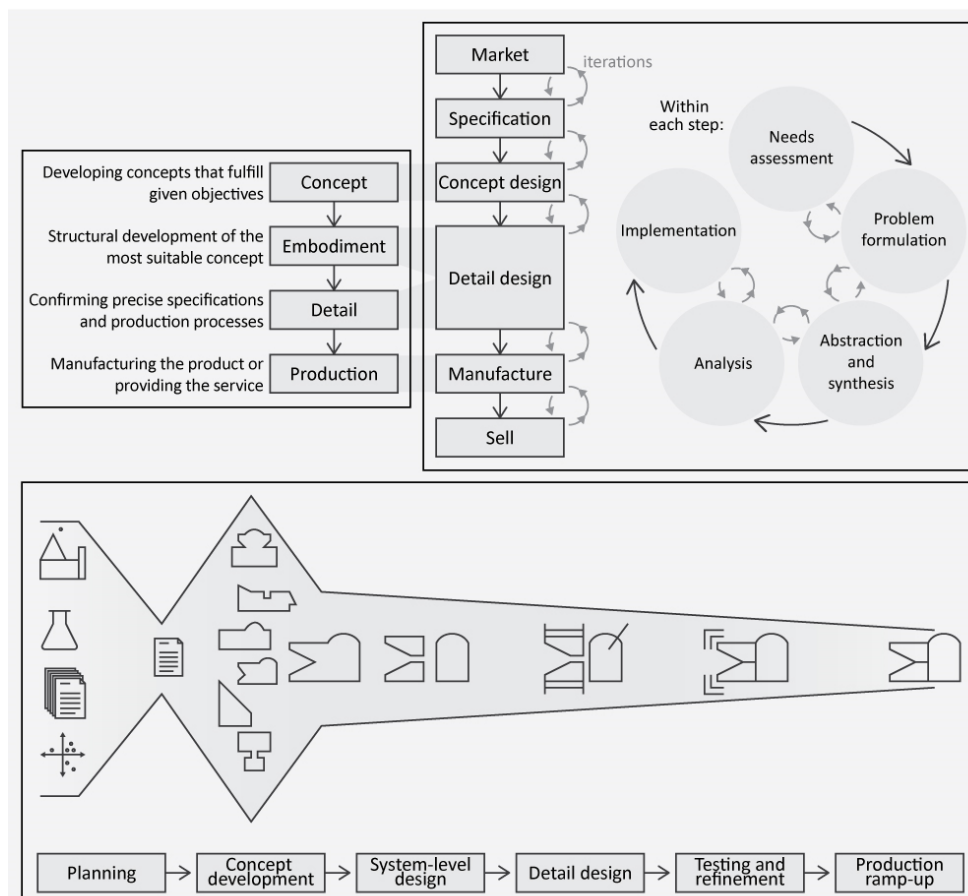


Figure 2.9 – The design process phases from Walker (1989), left; Pugh (1990), right; and Ulrich and Eppinger (2011), below (adapted).

The different phases can be described as follows using Ulrich and Eppinger's (2011) structure:

- **Planning and specification.** This initial phase sets the design brief, such as market and technical requirements, as well as the objectives for each of following phases. This is the most important phase in regards to Eco Design: *"otherwise there is the danger of it being merely a design criterion (a consideration in selecting the preferred solution) rather than a fundamental proposition inherent in the generation of potential design solutions"* (Deutz 2013, p.118).

- **Concept development.** This phase considers aspects such as the features of the product, the need of the user, and potential competitive products. It then provides different concepts and scenarios which are evaluated against the objectives of the design brief.

- **System-level (or embodiment) design:** Here, the systems, sub-systems and general components of the product are defined. One or more concepts are developed using technical drawings, visual prototypes, and looking at manufacturing feasibility. This phase also seeks feedback from clients and potential users.

- **Detail design.** During this phase, a concept design is selected from which the sub-systems and components are developed and optimised. Manufacturability, processes and materials are further defined and all components are fully specified. This phase also seeks feedback from clients and potential users. By this stage, Eco Design implementation has a much smaller impact (Deutz, 2013).

- **Testing and refinement.** This stage sees further development and refinement of the concept, using functional prototypes and testing, often by potential users. At this stage, more and more interactions occur with manufacturing to fine-tune the components for best reliability and cost.

- **Production ramp-up.** This stage sees the handover from the design team to the production team of the design; final details and remaining flaws are taken care of and first production series start.

Phase 0: Planning	Marketing - Articulate market opportunity. - Define market segments.	Design - Consider product platform and architecture. - Assess new technologies.	Manufacturing - Identify production constraints. - Set supply chain strategy.
Phase 1: Concept Development	- Collect customer needs. - Identify Lead users. - Identify competitive products.	- Investigate feasibility of product concepts. - Develop industrial design concepts. - Build and test experimental prototypes.	- Estimate manufacturing costs. - Assess production feasibility.
Phase 2: System-Level Design	- Develop plan for product options and extended product family. - Set target sales price point(s).	- Generate alternative product architectures. - Define major subsystems and interfaces. - Refine industrial design.	- Identify suppliers for key components. - Perform make-buy analysis. - Define final assembly scheme. - Set target costs.
Phase 3: Detail Design	- Develop marketing plan.	- Define part geometry. - Choose materials. - Assign tolerances. - Complete industrial design control documentation.	- Define piece-part production processes. - Design tooling. - Define quality assurance processes. - Begin procurement of long-lead tooling.
Phase 4: Testing and Refinement	- Develop promotion and launch materials. - Facilitate field testing.	- Reliability testing. - Life testing. - Performance testing. - Obtain regulatory approvals. - Implement design changes.	- Facilitate supplier ramp-up. - Refine fabrication and assembly processes. - Train work force. - Refine quality assurance processes.
Phase 5: Production Ramp-up	- Place early production with key customers.	- Evaluate early production output.	- Begin operation of entire production system.

Table 2.3 – Marketing, design and manufacturing considerations at the different stage of the Product Design process (adapted from Ulrich and Eppinger, 2011).

The Product Design process, as described above, provides a framework for designers and it is in turn the process that Eco Design needs to work along. As Stevels puts it: “*The extended paradigm for Applied EcoDesign is primarily to be derived from design approaches, not from Eco-approaches.*” (2009, p.20). This relationship outlines the initial necessity for a product design process to be in use

in order for Eco Design to be built upon (Short et al., 2012). The discipline of Eco Design therefore uses extensively this basis in order to define and structure itself, as developed below.

The Eco Design Process

“Design has a key role to play in reducing ‘man-made’ environmental impacts through processes such as ecodesign” (Dewberry, 1996, p.54).

The previous two sub-sections presented the concept of Life Cycle Thinking, the Life Cycle Assessment tool and the Product Design process. Together, these form the pillars of Eco Design, and Life Cycle Thinking and Assessment provides the environmental framework to approach and identify environmental impacts. However, by itself, this information is only descriptive. The Eco Design process translates the information into environmental impact lowering strategies and actions to be implemented along the design process. To do so, it presents the information and strategies using the Life Cycle Thinking segmentation, but adapts its process to work along the Product Design process (figure 2.10).

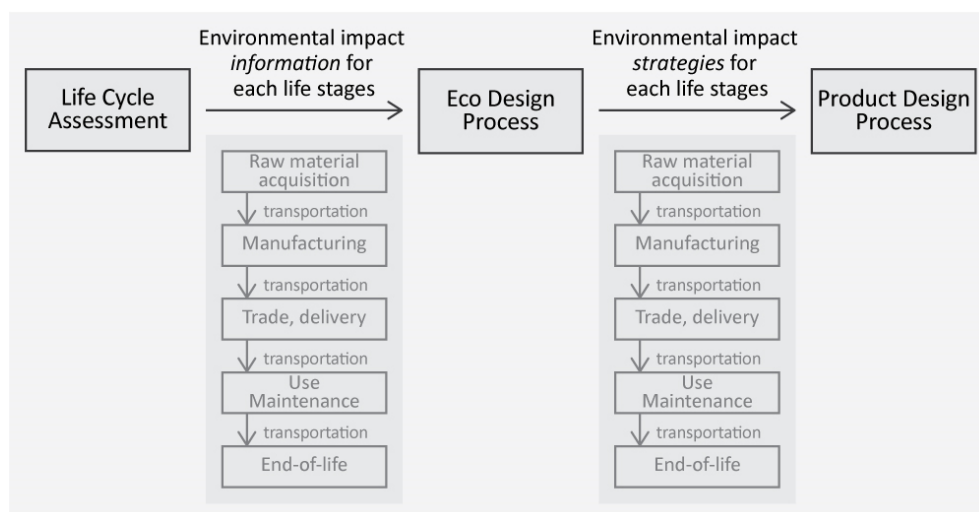


Figure 2.10 – The relationship between Life Cycle Thinking, Life Cycle Assessment, the Product Design process and the Eco Design process (adapted from Tischner et al. (2000), using insets from figure 2.6 (ISO 14062) to represent the product life cycle stages).

Descriptions of the Eco Design process in literature (such as in Tischner, 2000) may seem confusing as they seem to simply describe the Product Design process. This is because the Eco Design process is an 'added layer' to the standard process, or to put it a different way, Eco Design is another aspect (such as marketing or usability) to consider along each of the process phases. Figure 2.11 presents for each of these phases, the potential actions relating to the Eco Design process. The first phase of the process, the planning phase, is where most of the information gathering occurs and where environmental objectives and targets are set. The environmental impacts of a reference product are assessed, using Life Cycle Thinking; which determine the areas with most environmental impacts that need to be prioritised and worked on. The process then enters the conceptual phase. Design concepts including Eco Design strategies (such as lower material or energy use) are introduced before subsequent phases assess whether the objectives and targets are being met.

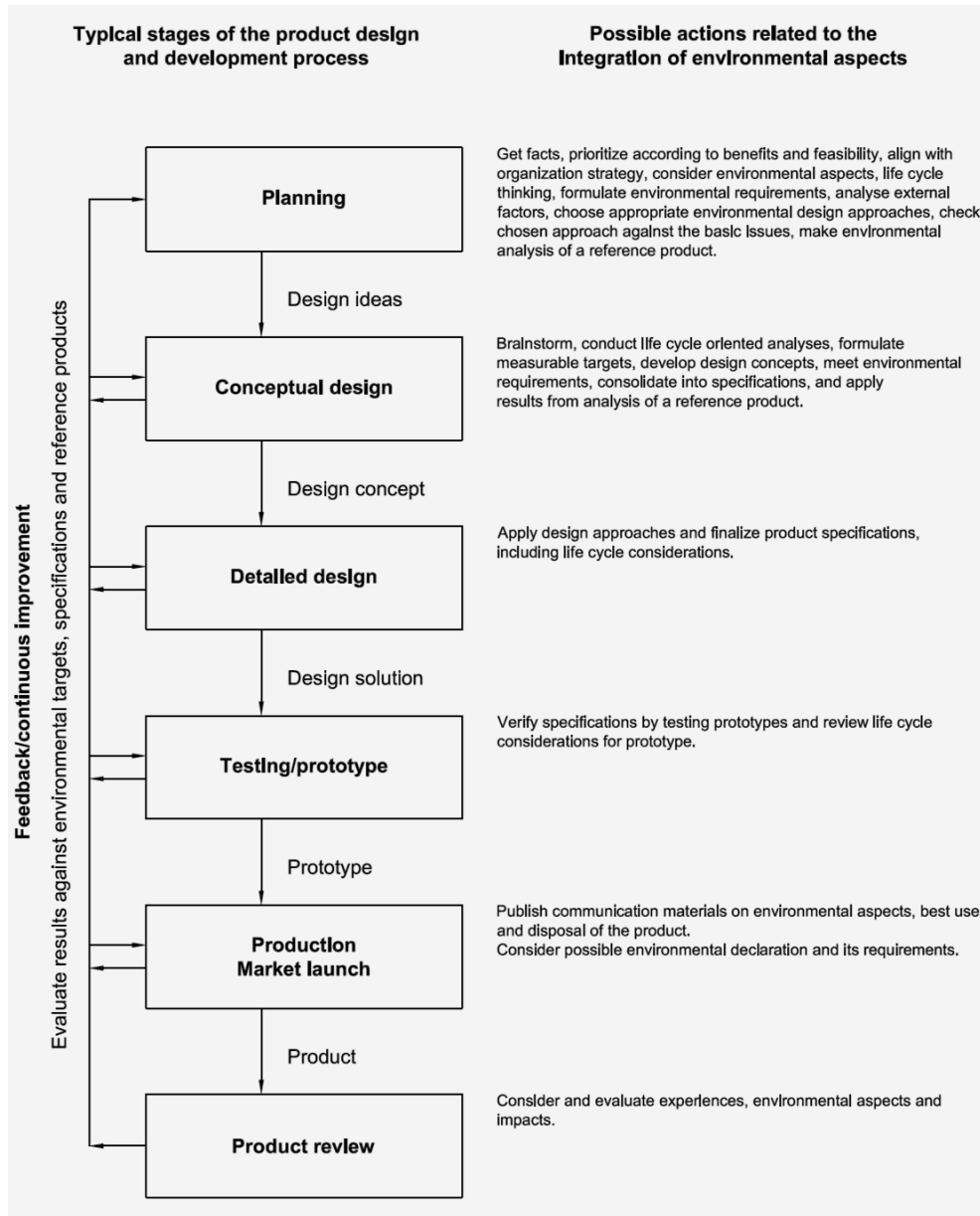


Figure 2.11 – Example of a generic model for integrating environmental aspects into the Product Design and development process (ISO 14062, 2002, p.15).

Following a Life Cycle Assessment, the Eco Design process can help address the largest environmental impacts by selecting one or more Eco Design strategies. These were developed by the end of the 1990s with, for example, the work of Brezet and Van Hemel (1997). The following table combining their work and that of the ISO 14006 (2011) lists both Eco Design strategies and identifies their relevance to the life cycle stages.

Eco Design Strategies	Affected Life Cycle Stage
Improvement of materials efficiency: <ul style="list-style-type: none"> - minimal use of materials, - use of low impact materials, - use of renewable materials, - use of recovered materials; 	<ul style="list-style-type: none"> - Materials extraction and processing - Transport - End of life
Improvement of energy efficiency: <ul style="list-style-type: none"> - reduce energy use throughout the product's life cycle (including use phase), - use of low impact energy sources, - use of energy from renewable sources; 	<ul style="list-style-type: none"> - Materials extraction and processing - Manufacture - Transport - Use - End of life
Sparing use of land	<ul style="list-style-type: none"> - Materials extraction and processing
Design for cleaner production and use: <ul style="list-style-type: none"> - using cleaner production techniques, - avoiding use of hazardous consumables and auxiliary materials - using an overall systems perspective to avoid decisions based on a single environmental criterion; 	<ul style="list-style-type: none"> - Materials extraction and processing - Manufacture - Use
Design for durability: <ul style="list-style-type: none"> - Increase longevity, - Design in reparability and maintainability; 	<ul style="list-style-type: none"> - Use - End of life
Design for optimizing functionality: <ul style="list-style-type: none"> - considering opportunities for multiple functions, - modularity, - automated control and optimization; 	<ul style="list-style-type: none"> - Use - End of life
Design for reuse, recovery and recycling: <ul style="list-style-type: none"> - ease disassembly, - reducing material complexity, - use of reusable, recoverable and recyclable materials, subassemblies, components and materials in future products; 	<ul style="list-style-type: none"> - End of life
Avoidance of potentially hazardous substances and materials:	<ul style="list-style-type: none"> - Materials extraction and processing - Manufacture - End of life

Table 2.4 – Eco Design strategies found in literature and their relationship to the affected life stages (original work).

In the search for clarification over concepts, academics have also developed categorisations for types of Eco Design. These are usually presented visually on graphs, with axes showing the different types across time and/or depth of environmental activities. Such categorisation or hierarchy is seen in popular textbooks such as Lewis et al. (2001), Charter and Tischner (2001) and Giudice et al. (2006). Brezet (1997) proposes a hierarchy within Eco Design on four levels, where more depth and environmental improvements are achieved over time (see figure 2.12). Brezet brings forward the idea that Eco Design is a lengthy and continuous process, suggesting that improvements occur at different levels according to the length of implementation of the process. This perspective joins that of Dewberry's (1996), also suggesting that Eco Design improvements first occur at a product level through to a systems level.

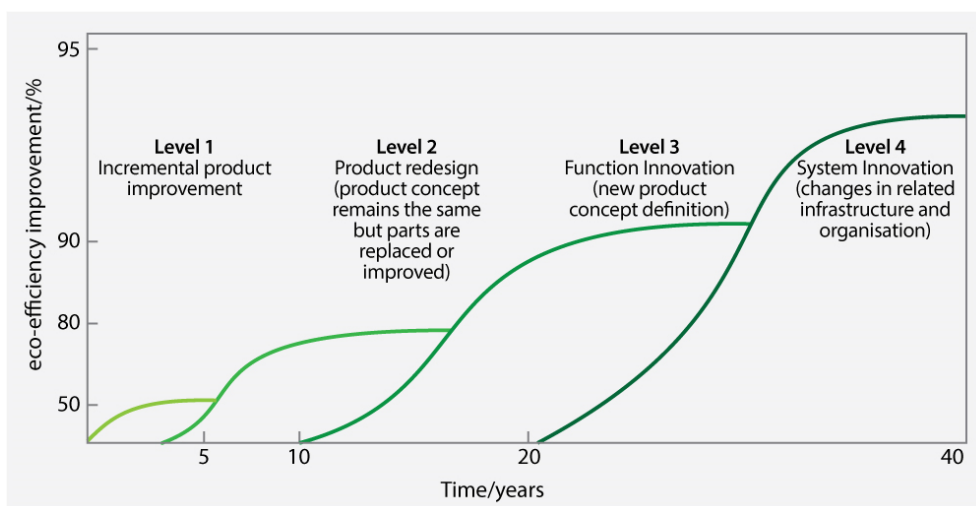


Figure 2.12 – Brezet's four levels of eco-design innovation (1997) (adapted).

To enable the implementation of Eco Design, academics developed Eco-Tools. These are introduced and described below.

2.4 Eco-Tools

This section presents an overview of the tools developed to help the implementation of Eco Design approaches; it reviews their emergence, development and classification before considering why they have been heavily criticised.

The Development of Eco-Tools

"In-house designers and design consultants are in a unique position to influence environmental strategy. The design profession can do this by changing its emphasis and by giving the environment a key place within product parameters. New design tools will have to be added." (Borsboom, 1991, p.40)

In the early 1990's, the first publications emphasising the role of product designers in the matter of Eco-Design appeared and a few years later a number of design methodologies for reducing environmental impacts were developed. These were mostly made of guidelines, checklists and general approaches (Van Der Horst and Zweers, 1994; Dewberry, 1996; Lenox et al., 1996). Life Cycle Analysis (LCA) also stood out from other approaches but was still in its infancy and lacked reliable quantitative data on the environmental impacts of materials and processes (Van Der Horst and Zweers, 1994; Dewberry, 1996). Klassen and Breis (1993) concur, stating: *"the different lifecycle assessment methodologies under development in North America and Europe are only beginning to reach an initial consensus"* (p.24). In order to aid this approach, a number of decision making tools have been developed, such as the SimaPro LCA data model (Dewberry, 1996).

By the mid 90's, Lenox et al. (1996) explain that there is both a deficiency in tools available and a lack of implementation of existing tools in industry. It is recognised that there had been much effort to develop tools, yet there is no mention of Eco-Tools as such (Dewberry, 1996; Lenox et al., 1996).

Eco-Tool, coming to a definition:

This area of research developed further the term Eco-Tool which, in 1997, Ehrenfeld and Lenox defined as:

“...artefacts, typically embodied in software packages or written design guidelines, which aid the detailed design of products.” (p.18).

Later definitions can be found in the literature, for example, by Baumann et al. (2002):

“finding ways of describing environmental aspects of material selection and generalised ways of dealing with environmental information” and “any systematic means for dealing with environmental issues during the product development process” (p.415),

and Bevilacqua et al. (2007):

“The basic idea behind this DfE [Design for Environment] methodology is to bring environmental expertise directly to the designers, either by integrating the environmental expertise into the design process or by using a software tool that ‘speaks the language of the designers’ and is integrated in their workflow” (p.4095).

However, by 1998, Simon et al. published the *Ecodesign Navigator*, a resource featuring a toolbox of 54 tools; showing the speed of the growth of Eco-Tools during the 1990’s. In 2000, Sherwin reviews the Eco-Design discipline and finds a relatively larger number of tools, *“there is a proliferation of principles and strategies and the resultant tools and methods” (p.32); “especially in post specification product development stages but still few for pre-specification stages, although thought to be of greater importance” (p.43).* Shortly after, Baumann et al. (2002) in their review of the green product development literature stated that: *“Tools of many different kinds were found in the literature, ranging from simple checklists to sophisticated computer-based expert systems, including technical*

strategies such as material substitution or dematerialisation. In all, in the literature review, more than 150 tools were identified.” (p.415). On the other hand, such a proliferation of Eco tools has an interesting research implication: *“the number of publications reporting on user aspects and on the effectiveness of tools is far lower than the numbers of publications that (conceptually) describe tools.”* (Baumann et al., 2002, p.415). Other reviews confirm these findings (Maxwell, 2004; Karlsson and Luttrupp, 2006; Byggeth and Hochschorner, 2006). One particularly extensive review from Pascual et al. (2003), encompassing about 850 Eco-Design conference papers in the 1998 - 2002 period shows that 67% of the papers focus on tools and methods for Eco-Design leading academics such as Lindahl et al. (2005) to doubt the need for more tools.

Nevertheless, the development of tools pursued its course and in 2006, Boks observes: *“there exists a wealth of idea, tools, methods, pilot studies, information and knowledge, from business, policy, as well as scientific perspectives.”* (p.1346). Additionally, Karlsson and Luttrupp (2006) argue that *“many researchers have been more interested in introducing new tools than evaluating or adapting existing ones.”* (p.415). By the end of the decade, the research starts to focus on tool customisation. Boks and Stevels (2007) foresee research will have to develop through *“Increased levels of customization of knowledge”* (p.4038) of existing tools. Mathieux et al. (2001) explains the reasons: *“Investing in the customization of tools and methods according to company practices and organization allows a design team to optimize the use of tools during the design process.”* (p.241).

At present, the focus remains on the use of varied LCA tools that allow designers a balance between practical use and quantitative information. CES Selector or Sustainability Xpress are some of these tools in a software form. In parallel, eco-guidelines are heavily relied on for qualitative information (Allione et al. 2012).

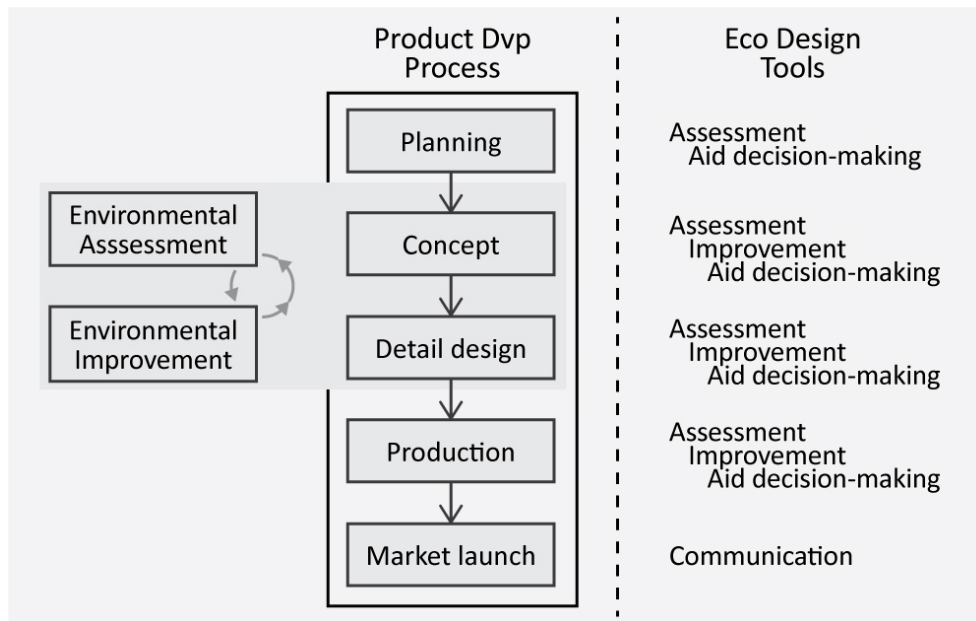


Figure 2.13 – Types of Eco-Tools, Le Pochat et al. (2007, p.672), (adapted).

The Classification of Eco-Tools

“Researchers have categorised ecodesign tools in many different ways, with few common features in their work” (Knight and Jenkins, 2009, p.555).

Since the early developments of Eco-Tools, categories were introduced to identify the different types of tools. The evolution of this classification has been quite organic and many references have proposed different sets of categories, without consensus. The classification of tools has also been a way to establish which phases of the design process and life cycle of a product each tool was devised for. Some of these classifications are presented below:

Lenox et al. (1996) offer a classification scheme based on three dimensions. The first concerns the applicability to different product development phases; the second dimension is about the applicability to various product life cycle phases; and the third regards the degree of decision support.

From a different perspective, Charter and Tischner (2001) create four categories for Eco-Tools which correspond to the environmental management process: *“Analysis of Environmental strengths and weaknesses”*, *“Setting priorities*

and selecting the most important potential improvements”, “Implementation: providing assistance for design, brainstorming and specifying the details of ideas”, “Coordination with other important criteria: cost-benefit analysis, economic feasibility studies” (p.65).

Baumann et al. (2002) classify the tools from both supply chain and methodology perspectives. The supply chain categories include: *“within product development”, “within the company”, “within the product chain” and “within society”*. The methodology categories are: *“Frameworks”, “Analytical tools”, “Checklists and guidelines”, “Rating and ranking tools”, “Software and expert systems”, “organising tools”*.

Allione et al. (2012) provide a pragmatic divide between, on the one side, quantitative, and on the other, qualitative tools. The quantitative tools relate to assessment and inventory Life Cycle Analysis tools. The qualitative tools *“such as eco-strategies & guidelines, materials library & databases, supply general or specific information about the materials and their manufacturing process or suggest some best practices”* (Allione et al., 2012, p.91-92).

In all, these classifications help in understanding the different areas that Eco-Tools tackle and consequently the area of research academia and industry focus on.

The Critique of Eco-Tools

“Those involved in the field are more interested in developing new Eco Design methods rather than studying the utilization of existing ones in order to evaluate and improve them.” (Baumann et al., 2002)

From the development of early Eco Tools, academics have suggested that communication and integration were key factors in Eco Design success. In 1991, Borsboom stresses that: *“among the most important [tools] is communication in the early stages. The cross-functional abilities of a design department will be a*

major asset” (p.42). This belief is shared and further researched during the following decades by, to cite a few, Lenox et al. (1996), Baumann et al. (2002), Boks (2006), Le Pochat et al. (2007) and O’Hare (2010). There is consensus that the lack of implementation of Eco-Tools is due to not integrating the needs of the product development process and of the organisation into the tools. Baumann et al. (2002) and Pigosso et al. (2013) go further and explain that management and organisation seem more important to the success of Eco Design than the tools themselves. While Eco-Tools remain a critical component for Eco Design, it is worth noting *“Typically successful firms have been able to do DfE without relying heavily on tools.”* (Ehrenfeld and Lenox, 1997, p.19).

There is also strong criticism from academics regarding the abundance of Eco-Tools developed in literature, as underlined by Baumann et al. (2002): *“Too much tool development: references indicate that those involved in the field are more interested in developing a new tool than on studying the use of existing ones and to evaluate them in order to improve them”*(p.421). Moreover, there is *“In some cases, [...] little or no testing of these methods and tools in industrial practice.”* (Lindahl, 2005, p.225) and *“Although there are quite a lot of DfE [Design for Environment] tools developed by academia and industry, few have made a significant breakthrough so far.”* (Bevilacqua et al., 2007, p.4076).

Another critique to Eco-Tools development has related to their ease of use (Le Pochat et al., 2007) with the result that motivating designers to use them has been difficult; *“tools are poorly understood and rarely used.”* (Handfield et al., 2001, p.202). Moreover, there seems to be a misalignment again between the needs of the users (i.e.: the designers) and existing tools (Lofthouse, 2006). As a result, there is a consensus that *“Developing new tools would do very little to address the [...] concerns raised by the designers.”* (Handfield et al., 2001, p.204). (Schiavone and Pierini (2008) emphasises this point, explaining that: *“companies, managers and designers look for simple and exhaustive approaches and consistent, user-friendly tools for simplifying decision-making.”* (p.31).

Parallels can be noted between this lack of consensus and common directions in Eco-Tools research on one side, and the lack of diffusion and implementation of Eco-Tools on the other. The development of Eco-Tools emerged

20 years ago and has become since, in academia, an inherent part of Eco Design and more generally of Product Design. However, as described in the following section, their diffusion in industry remains rather low.

2.5 The Implementation of Eco Design

This section reviews the research on adoption and implementation of Eco Design, the methodologies used and the observed drivers and barriers to implementation.

The Lack of Research on Industry Practice

“Despite the apparent benefits of eco-design [...], evidence of actual implementation is sparse” (Knight and Jenkins, 2009, p.449)

In the literature, few studies focus on the implementation of Eco Design in industry and even fewer observe the potential drivers and barriers to implementation. The lack of research in this topic has been repeatedly voiced throughout the last decade, by academics in the field such as: Lindahl (2005), Lofthouse (2006), Knight and Jenkins (2009), Arana-Landin and Heras-Saizarbitoria (2011), and are well summarized by the work of Deutz et al. (2013) that argues that *“there is a lack of a broad based study providing a characterisation of eco-design practices in industry”* (p.118). Here, the key part of the claim is *“broad based study”* and *“providing characterisation”*. Indeed, this is not to say there are no studies reporting on the implementations of Eco Design approaches and tools. However, there is a clear lack of representative studies with large samples (broad based studies) which could provide an understanding of the different characteristics of Eco Design implementation (characterisation studies). Following the criticism about the over-development of Eco Design conceptual tools and the lack of empirical

material (Baumann, 2002) there has been an increasing trend to show success stories on the implementation of newly developed tools as proof of concept and other illustrative examples of Eco Design practices in product developments. These studies however usually base their findings on very small samples, which do not meet the criteria of “*a broad based study providing a characterisation of eco-design practices in industry*” (Deutz, 2013). The remainder of this section discusses these studies, their aims limitations and pitfalls, as well as their contributions to the field in order to provide a basis for the present research.

Because of their different methodological approaches and data collection focus, Eco Design studies cannot be directly compared and neither can their findings be compiled to form an overall picture of the topic’s landscape. However discussion can be based on certain common criteria (table 2.5). First, regarding their methodology, there are three main categories: the sampling type (ranging from random to convenient), the population size (from one to a few or many companies) and the method(s) used (e.g.: case studies and/or surveys). These factors determine to a large extent the reliability and generalizability of the studies. Secondly, there are criteria that relate to the data collection itself: the type of observation (i.e.: the implementation and testing of a specific existing or new approach or the exploratory investigation of what is practiced) and the observed area (i.e.: the overall product development activities or the specific real-life or given product development). These categories and criteria are further discussed and explored in the following methodology chapter in regards to this current research (section 3.2). As a complementary layer of distinction; there are the ‘success stories’ that provide an account of the implementation of an Eco Design approach, usually developed by the same researcher. By nature, these studies are not exploratory; they do not provide much leeway for generalization and are often the result of controlled experiments – for which they can be criticized (Lindahl, 2005).

Sampling type	<ul style="list-style-type: none"> - Random Sampling - Sampling: 'More likely Eco Design', e.g.: part of an innovation hub - Sampling: Companies developing Eco Designed products - Sampling: Selected Positions, e.g.: Managers only - Sampling: Test Company
Population size	<ul style="list-style-type: none"> - A company - Very small number of companies - Large number of companies (over 10)
Method used	<ul style="list-style-type: none"> - Case Studies - Survey
Observation	<ul style="list-style-type: none"> - Implementing / testing a specific existing or new approach - Exploratory investigation (what approaches, if any are used)
Observed areas	<ul style="list-style-type: none"> - Overall activities analysed - Specific Product Development analysed (either company project or given 'example project')

Table 2.5 – Categorization of research designs in articles looking at the Eco Design practices in industry (original work).

The research design of success stories usually takes shape across either one, or a few, specific companies and often relate to previous theoretical or conceptual academic work (i.e.: the development of an Eco Tool). These are illustrations of *“detailed case studies of a very small number of companies, often selected as examples of good practice and commonly analysing the experience of implementing a specific approach”* (Deutz, 2013). In these studies, researchers report on the implementation of a certain approach, method, tool they developed in universities on a selected few, willing, companies (Baumann, 2002). The artificial implementation by academics of an approach they created and thereafter surveyed and analysed themselves limits the reliability and generalizability of the research because the observations derive from environments highly-controlled by one party. This presents bias where the academics are both the creator and the evaluator of their work (such concerns were taken into account devising the methodology of this research and are addressed in the following methodology chapter, section 3.3 through 3.5). Le Pochat et al.'s article (2007) on the implementation of an Eco Design approach is a good example of this type of research. The research first finds

gaps and limitations in Eco Design approaches; then argues the need for a remedial approach before presenting a success story of implementation with several companies. They claim the positive effects of their implemented approach before providing the limitations of their work, especially regarding the size of the study; suggesting further research for the validation of their results. Such studies populate the literature (Baumann, 2002), but they only provide contextual understanding, since the ability to generalise the findings is compromised by the use of unique methodological approaches and new tools. Another example for this argument is the work by Luttrupp and Lagerstedt (2006), in the presentation of their *"Ten Golden Rules"*. Here, the authors' claim *"that there is a strong need for a tool to facilitate the integration of [Eco Design]"* (p.1396) is representative of this body of work in the literature. However, the implementation and testing of the tool is, at the very least poor and it only consists of occasional comments from employees. Jamie O'Hare's development of an 'Eco-innovation toolbox' for his PhD research (2010) provide the same type of research, claiming the need for new tools before creating then assessing his own. For those studies, *"common explanations in research reports, papers and dissertations as to why methods and tools are seldom validated are lack of time and that the validation is outside the focus of the research."* (Lindahl, 2005, p.15-16)

Another type of study to be mentioned looks at the implementation of existing tools not developed by the researchers. Arana-Landin and Heras-Saizarbitoria (2011) offers this angle by looking at the implementation of an Eco Design tool in four selected companies. Here, there is little detail on the sampling methods, apart from the fact that all four companies studied are pioneer users of the tool. This seems to show, once again the aim of the study to present success stories, by using an unrepresentative, biased sample. Within this type of study, as Deutz (2013) mentions, some select examples of 'good practice', where companies lead the use and implementation of Eco Design. They look at the implementation of Eco Design in companies sampled for developing Eco Designed products. However, it is worth asking: what constitutes 'good practice' in Eco Design? More specifically; how can one label a company or product as part of the good practice group if there is no empirically researched industry baseline?

Moreover, some of these studies are not the external, non-disruptive observation of a researcher; but the outcome of a project, either instigated or influenced by that researcher. The researcher creates an approach or tool, to be tested in a particular setting, observed by the same researcher - and then reported. Although the aim is to understand and synthesize the aspects that make Eco Design implementation successful; these studies focus too much on success stories and lack records of failed projects, which would be as useful to provide new knowledge and understanding of implementation. The lack of random sampling in these studies results in the impossibility of validating the findings to the wider Product Design industry. This brings us onto a common theme of sample bias problems. Most studies test the use of Eco-Tools within non-representative samples or experiment-based observations (such as Vallet et al., 2013); which again, does not show what the state of Eco Design implementation is in any particular area. Even by looking at the findings across the whole body of the literature; this problematic sampling and bias in studies makes it very difficult to trust and generalise the state of the Eco Design implementation across the industry. This means that even to date, *“evidence of actual implementation is sparse”* (Knight and Jenkins, 2009).

Confusion also arises in terms of the meaning of ‘Eco Design activity’. For example, Cordoba and Veshagh (2013) presents a survey looking at *“Eco Design and Sustainable Manufacturing”* but using the pre-defined understanding of the terms Eco Design, they do not look specifically at design teams or product development. The survey instead provides information on the opinion of manufacturers on environmental strategies with no knowledge of the respondents’ job roles.

The Factors Affecting Implementation

Bearing in mind the limitations of the current published studies on Eco Design implementation, the section below offers a review of the different factors affecting Eco Design implementation in Product Design.

All of the following drivers and barriers tend to come from one of two sources and from case studies or questionnaire populations of less than a hundred respondents. Therefore, it is difficult to take the following findings as

representative of those who engage in Eco Design. The studies also focus on different segments of the 'design' sector. Some represent the study of manufacturers, some of engineers, some of country vs country, SMEs vs Large Companies; the variables are consequently too large to identify this set of findings as universal. These methodological strengths and shortfalls helped devise the methodology of this research and are discussed in sections 3.2 and 3.3 of the following methodology chapter.

From the beginning of the 2000's, the Eco Design literature shows an increase in attempts to investigate the lack of implementation of Eco Design tools and strategies. The factors this trend highlights relate to the different phases of implementation of Eco Design strategies or tools. From the content presented in literature, the phases can be viewed as follows: consideration, selection, implementation and use. The consideration phase regards the often on-going phase where the design team considers the viability of implementing Eco Design. This phase can also be seen as forming the opinion or views of the design team in regards to Eco Design. The selection phase is the phase where the design team considers the approaches, strategies and/or tools to implement. The implementation phase happens after the selection of the Eco Design approach for the team. The use phase regards the continuous use of the Eco Design approach. In all phases, there are both enabling and hindering factors.

For each of these phases, the literature provides findings on the factors that hinder the implementation of Eco Design. Similar themes, often occurring in more than one phase of implementation, are presented below:

***Demand – Time:** relates to the lack of demand from clients and or time allocated in product development to Eco Design activities.*

“Barriers are that clients don’t want to know because there is no commercial benefit...” (Dewberry, 1995, p.173, quote from one of the interviewees)

One of the main aspects the literature outlines is a general lack of demand in the form of design requirements from the customer (Dewberry, 1996; Lindahl,

2005; Luttrupp and Lagerstedt, 2006; Olundh, 2006). In the Design Council's Insight Research from 2010, *"only 16% of design consultancies told the Design Council [Eco Design] was an important factor to win work"* (p.19). However, in the cases where clients make Eco Design part of the requirements, demand is an important driver for Eco Design. Van Hemel's survey (1998) of SMEs found customer demand to be the biggest external stimuli for Eco design implementation.

The lack of demand is often associated with a lack of time and vice versa. This is partially because the Product Design industry, more often than not, provides incremental changes to products rather than radical innovation. With the exception of a few innovators (e.g.: Apple, creating new consumer needs through new product categories), the Product Design industry mostly develops products in direct relation to market trends (Sroufe et al., 2000). This is not limited to the inclusion of environmental concerns, and in fact relates to all aspects of innovation in the design process (Deutz, 2013). As O'Hare puts it: *"The demands of incremental NPD projects on staff time hinder a company's ability to generate and execute radical innovation projects, including eco-innovation projects."* (2010, p.265). Another dimension to this lack of demand and time relates to an initial lack of room to spend on training the design team on Eco Design (Dewberry, 1996; Lindahl, 2005; Short et al., 2012). This aspect is developed further in the 'knowledge' theme section.

Selecting the right Eco Design approach for the design team is an important task, as the Eco Design process needs to fit the Product Design process used by the team. However, because this process does not take place during project time and is not billed for, it does not take priority. Moreover, it is time consuming, especially due to the lack of awareness of the tools (see below), and due to haste, or lack of knowledge, product designers can end up using the wrong tools or no tool at all (Ernzer et al., 2002; Knight and Jenkins, 2009). The following phase of implementation of the Eco Design approach is seen to be too time-demanding and its outcomes not necessarily worth the investment (Lindahl, 2005).

Discussing her findings, Dewberry explains: *"The main concern was the need for greater amounts of time in order to understand the implications of new environmental criteria within the whole design process."* (1996, p.176) and *"Time was a key issue as it related directly to cost."* (p.186). 20 years later, Eco Design

remains a fringe, innovative field within product design. Investigation in this domain requires a considerable amount of resources (such as time) to investigate, that design teams simply do not have.

***Awareness:** regards the lack of awareness of the existence of, or difference between, the available Eco Design approaches, strategies and tools. It also includes the lack of awareness within the wider design team and stakeholders.*

The lack of awareness from product designers about the available Eco Design (Dewberry 1996) as well as Eco-Tools is a hindering factor reinforced by their lack of marketing that in turn considerably constrains their potential to be implemented (Araujo, 2001; Lindahl, 2005). The free availability of these tools does not help with their visibility; designers simply have little knowledge of the existence of possibilities.

At the selection phase, designers are now aware of the existence of Eco Design and Eco Design tools, and look for an approach appropriate to their design process. However, the vast multitude of tools developed by academia and industry makes the selection difficult and is compounded by their lack of available review, critique or analysis (Araujo, 2001). There is therefore a lack of platform for these tools to be showcased and The Design Council, for example, offers very little in this area.

During the implementation of the Eco Design approach, there seems to be a lack of internal consultation and collaboration which hinders their adoption and ultimately, their success (Ernzer et al., 2002; Boks and Pascual, 2004; Lindahl, 2005). There is also a lack of external consultation (with clients) which is seen as another obstacle to implement successfully an Eco Design process (Deutz, 2013).

***Process:** relates to a lack of primary design process and difficulties incorporating a secondary process (Eco Design).*

Another important theme, especially before the actual implementation phase, regards the lack of importance given to the design process itself, let alone Eco Design processes. From their survey, Short et al. (2012) explain, only 30% saw the Product Design process as a priority. The implementation of a secondary Eco Design process is therefore very unlikely for those companies.

Lindahl (2006) and Araujo (2001) both mention a certain ambivalence between the need to use tools and processes to save time and the lack of time to use them. Araujo (2001) also mentions the negative attitude towards the introduction of new processes, and generally, a certain fear of changing the workflows of the design process. While design tools are usually used to help increase productivity, Eco Design is seen as an optional activity with goals potentially hindering those of the primary design process (Lindahl, 2006).

Le Pochat et al. (2007) as well as Ritzén and Lindahl (2001) find there is also a lack of formal introduction process to Eco Design approaches. In other words, tools do not contain guides for their introduction. In turn, the Eco Design processes are introduced without formal analysis of the needs of the design team, which largely hinders successful implementation.

Although, as developed in previous sections, the Eco Design process is theoretically aligned to the Product Design process; Eco Design tools have limited information about how they fit within the wider Product Design process (Lindahl, 2005). Going further, Stempfle and Badke-Schaub (2002) explain the tools are developed with a neglect of the need to understand designers' workflow and processes. Blessing (2002) also supports this idea, mentioning the tools seem to work in isolation of the design process.

Knowledge: covers the lack of Eco Design knowledge from the design team and the stakeholders involved in the product development process.

The Product Design industry also shows a lack of knowledge in Eco Design where “Few designers feel their ability to provide green advice is important” (Design Council, 2010, p.19). This may be due in part to the newness of the discipline but

Deutz (2013) also identifies in his study a clear lack of training on environmental issues and Eco Design. It is not obvious whether this lack of training affects Eco Design awareness and subsequently the consideration of an Eco Design approach or whether it is a consequence of not considering that approach. This theme also relates to the way knowledge development occurs in Product Design, and to an overall lack in training in the product industry (Design Council, 2005).

Looking for Eco Design approaches, designers are faced with approaches developed with a scientific and theoretical background that is too disconnected from their expertise (O'Hare, 2010; Short et al., 2012). As Dewberry's research shown, designers feel "... *environmental information to date [is] confusing and too scientific*" (1996, p.174). There is a certain lack of appeal (Araujo, 2001) and the tools simply seem too difficult to understand (Handfield et al., 2001; Tukker et al., 2000; Tukker and Eder, 2000).

The lack of knowledge also plays an important part in the implementation phase. "*The lack of expertise is a barrier to the participation of the company's staff in the Eco Design process and thus there is a need for knowledge and skills creation.*" (Le Pochat et al., 2007, p.678). The required knowledge in Eco Design as well as Life Cycle Thinking is lacking in order to obtain successful implementation (Handfield et al., 2001; Lindahl, 2005; Aschehoug, 2012; Deutz, 2013). The Eco Design tools usually focus on the theoretical background to the process without providing training, exercises or guidance on Eco Design strategies; this hinders designers' abilities to transfer the knowledge into practice (O'Hare, 2010; Short et al., 2012).

Trust: this last theme highlights how a lack of trust in Eco Design may hinder implementation.

The main factor behind the lack of consideration of Eco Design processes relates to the scepticism that exists in the Product Design industry towards the benefits of Eco Design, but also towards tools and methods generally (Lindahl, 2005; Cross, 2000). Designers are "*aware that many previous environmental claims from manufacturers turned out to be false which had resulted in consumers being dubious of 'green' credentials*" (Dewberry, 1996, p.184). This tends to come from

confusion rather than an aversion as to how these could be helpful (Araujo, 2001). But there is also scepticism regarding the return on investment to the use of Eco Design approaches and tools (Lindhahl, 2005). In turn, this seems to relate to a lack of Eco Design knowledge, of the advantages of Eco Design approaches and of the availabilities of tools, as observed by Lindahl (2005).

There also seems to be a lack of trust regarding the commitment of the designers' clients and/or management team (Sherwin, 2000; O'Hare, 2010). Design teams feel the sudden push for Eco Design may not be long lasting and not worth investing in Eco Design approaches and tools.

Overall, these themes show the difficulties designers have in reaching Eco Design, as well as their lack of trust in the process. In regards to the development of Eco Design tools, there seems to still be a failure to respond to the needs of the designers although, this is to be balanced against a lack of education and training.

Conclusion

Eco Design is mainly concerned with lowering the environmental impacts of products or services through the pursuit of reduced carbon footprint, increased recyclable content, weight reduction, etc... (House of Lords - Science and Technology Committee, 2008). Much of the research in this area has focused on the development of eco-tools: *"finding ways of describing environmental aspects of material selection and generalised ways of dealing with environmental information"* (Baumann et al., 2002). Other research concentrates on the use of case studies to illustrate the potential of these tools and other Eco Design applications in industry.

While Eco Design has received much academic attention over the last two decades (Boks, 2006; Baumann et al., 2002), in industry, the take up of Eco Design is limited (Tukker et al., 2001; Boks and McAlloone, 2009). The Eco Design scene has

evolved considerably academically but its implementation in industry is still lagging. It is thought this research can start to address this problem by investigating the Eco Design related practices of British design teams to further identify the possible success factors and barriers of Eco Design implementation.

Chapter 3 - Methodology

Chapter 1 introduced the reader to the specific nature of this research as well as the related aim, objectives and research questions. Chapter 2 introduced the relevant literature, research gaps, as well as some of the methods used in Eco Design research. Following from this, the aim of this chapter is to identify a research design as well as the research methods to be used to gather the necessary data, provide suitable answers to the research questions, and achieve the aim of this research. This chapter tackles the different aspects of methodology, from the more general choices (regarding research strategies) to the more specific ones (e.g.: research designs). This is done along the following sections by discussing and debating the potential orientation the research could take, before making the appropriate choices. The chapter first introduces the type of research strategy in section 3.1, and explores further in section 3.2 what will constitute the research population, sample and unit of analysis for the research. Section 3.3 then discusses aspects of research quality, before reviewing and selecting the research design in section 3.4 and methods of data collection in section 3.5. The methods of data analysis are later discussed in the research chapters 4, 5 and 6.

3.1 Research Strategy

In order to establish how the necessary data will be collected, there is a need to consider the appropriate research strategy to adopt. This mainly regards deciding on the main type of data to collect: quantitative or qualitative. This section presents a definition of the two strategies and the reasoning for the choice made.

Quantitative research is concerned with numbers, statistics and norms; and looks at occurrences across large samples but in controlled environments. Qualitative research on the other hand, is concerned with social constructs and is interpretive. In qualitative research, there is a “*conviction that what is important to look for will emerge*” (Holliday, 2007, p.6). Qualitative research seeks to gradually build images of complex realities. As developed by Bryman (2008), there are fundamental differences between qualitative and quantitative research strategy. In terms of principal orientation, a research strategy can either set out to test or generate theory (be deductive or inductive). Qualitative research is usually used to generate theory and therefore associated with an inductive approach. Results from qualitative research strategies can then be tested in different settings or across multiple settings, using quantitative data collection methods.

"Qualitative research is a research strategy that usually emphasizes words rather than quantification in the collection and analysis of data." (Bryman, 2008, p.366).

The aim of this research is explorative and descriptive (*to review the level and type of Eco Design thinking in the British Product Design industry and to identify recurrent themes helping or hindering Eco Design implementation*). It is firstly explorative because the research is not interested in proving a theory, quite the opposite; it is interested in finding out what is happening in the practice of the Eco Design discipline. Secondly, it is descriptive because the research is interested not in creating a new method or tool, but in providing the field of Eco Design with an

accurate description of practice. The objectives presented above are likewise using research action verbs such as: *to review, explore, observe and identify*. Furthermore, this research is interested in collecting rich data to provide an *in depth and timely picture* of the field of Eco Design. Due to its explorative nature, this research is more interested in meaningful descriptions, rich pictures and observations of the Eco design field, rather than numbers and percentages. Indeed, the research is focused on descriptions, accounts, stories and the collection of similar data that best suit a qualitative research strategy. Also in most cases, as Bryman (2008) notes, a qualitative research strategy is usually undertaken first in new fields of social research, of which Eco Design is arguably part of. This research will therefore follow a qualitative research strategy. It will gather knowledge on the practice of Eco Design and look for recurrent patterns to allow a generalization of the data.

This strategy does not however rule out quantifiable metrics altogether, as they can help the research develop a structured frame of enquiry. Indeed, it is essential to develop constraints and limitations to outline and define the area of research and the area of data collection. In this sense, this research will also make use of quantitative data; data about the size and shape of the industry (introduced in chapter 1, and discussed further in the following section).

However, in qualitative research, there can be problems regarding subjectivity and how to preserve scientific rigour. This is overcome through systematically constructing the research methodology (set out in the following sections of this chapter) and by thoroughly documenting every step of the research and explaining how the results were obtained (throughout the research chapters).

3.2 Research Population, Sample and Unit of Analysis

An initial consideration when developing a research methodology, and before going into research design or methods, is to define who and/or what will best provide the appropriate information to investigate and analyse. This ensemble of potential 'whos' and/or 'whats' will form the research population, while the investigated ones will form the research sample and each individual one will be a unit of analysis. This section presents, in turn, the definition for population, sample and unit of analysis and what they mean for this research.

In qualitative research, units of analysis usually relate to people possessing certain common denominators such as age, income or sport practiced. However, they can also be nations, cities, regions, organisations, etc. (Walliman, 2006). In all cases, the population encompasses all single units that have the attributes to provide relevant knowledge to answer the research questions. Defining the research population also serves to keep the research focused and to set boundaries to ensure the right type of knowledge is gathered. It is also important to recognise that these limitations can evolve during the research process. In the light of new findings, the research may have to consider refocusing its enquiry on unexpectedly relevant 'whos' and/or 'whats'. This is especially true in qualitative research, as discussed in the following sections.

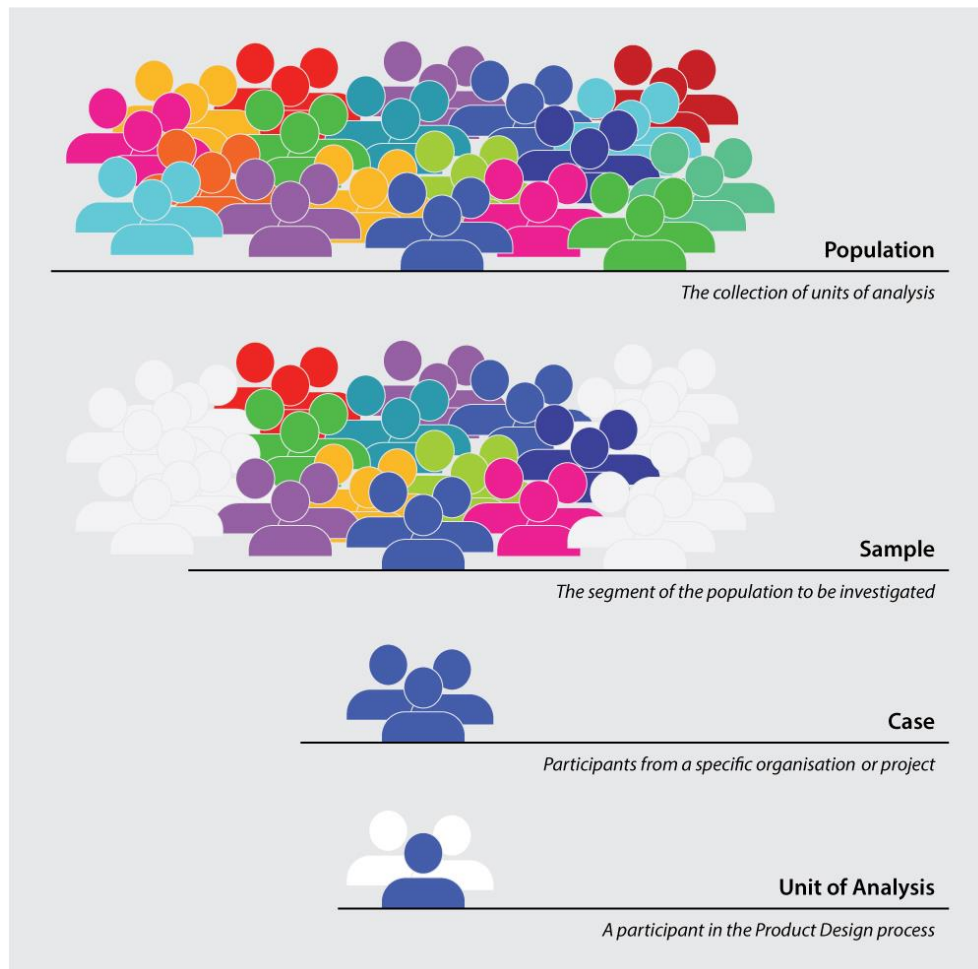


Figure 3.1 – Representation of the population, sample, case, and unit of analysis in relation to each other (original work).

Research Population

"Population: basically, the universe of units from which the sample is to be selected." (Bryman, 2008, p.168)

Establishing criteria for case study selection is very important. However, it is also important to recognise that it is rarely possible to find the ideal research conditions (Holliday, 2007) and that opportunism and case availability play a clear part in every study. All along the research process, this needs to be balanced by maintaining the principles of social science by documenting what was done and why.

In the case of this research, and as a first selection criterion, the population is first bounded geographically to the United Kingdom, which will allow generalising

the results to the wider British Product Design industry (section 1.5). Pragmatically, this boundary will allow the researcher to investigate a manageable sample size and yet offer generalisation of the data. The population is also limited to the Product Design industry and profession, practiced both by companies with a larger purpose (within in-house design teams) or by those with product design for sole purpose (within design consultancies or by freelancers). This segmentation follows that of the Design Council (Design Council, 2005), as developed in table 3.1.

Design businesses working in product and industrial design

Product and industrial design businesses account for just over 10% of the UK's design businesses. The discipline is well established in the UK. Over a third of product and industrial design businesses have been operating for 15 years or more, although the number of in-house design teams and freelance designers working in product and industrial design has fallen since 2005. [...]

How many designers work in in-house product and industrial design teams?

0-4	38%
5-9	25%
10-49	29%
50+	7%

How many designers do design consultancies working in product and industrial design employ?

0-4	67%
5-9	21%
10-49	11%
50+	1%

Just under 90% of product and industrial design consultancies employ less than 10 designers.

Table 3.1 – Excerpt from the 'Design businesses working in product and industrial design' (Design Council, 2005) (adapted).

The study population is made of people able to inform, through investigation, on the state of the art of Eco Design in the Product Design industry. However, this does not limit the population to product designers but includes those that participate, influence and are involved in product development projects – product designers, product design managers, Eco Design consultants, managing directors to name some. Pagell and Wu (2009) suggest that using different industries and economic sectors offers more opportunities to generalise the results and to obtain a fuller spectrum of practices. The cases' industry (e.g.: white goods, electronics or furniture) will therefore not be a criterion for selection.

Research Sample

“Sample: the segment of the population that is selected for investigation. It is a subset of the population.” (Bryman, 2008, p.168)

The sample for this research, in the same way as its population, needs a balance between boundaries and limitations on one side, and relevancy and richness on the other. Too small, and the sample will not offer enough data to generalise and depict a valid picture of the population. Too large, and the sample will be unmanageable and results will be impossible to process. Another aspect to consider is the opportunity in sampling, getting access to the data. Developing a sample needs to be a pragmatic task as its disconnection from the real world may make it unattainable. For this reason, the researcher must gauge its population to understand the opportunity to engage with the units to investigate. These considerations altogether will, with exploration of the population (see chapter 4), craft the sample for this research.

In order to investigate a representative research sample (*“a sample that reflects the population accurately so that it is a microcosm of the population”* (Bryman, 2012, p.187)); either one of two ways can be adopted: a probability or a non-probability sample. A probability sample is simply made of a random selection of units. However, within the context of this research, all units are not likely to accept to be investigated. Therefore, a non-probability sample is preferred. This may create sample bias, where the researcher creates a situation where *“members of the population [...] stand little or no chance of being selected”* (Bryman, 2012, p.187) because of opportunity access or personal preference. This can be avoided by making sure to balance opportunity, keeping focus on what the population is made of. To a certain extent, this non-probability sampling method closely relates to the features of convenience sampling: *“A convenience sample is one that is simply available to the researcher by virtue of its accessibility.”* (Bryman, 2008, p.183).

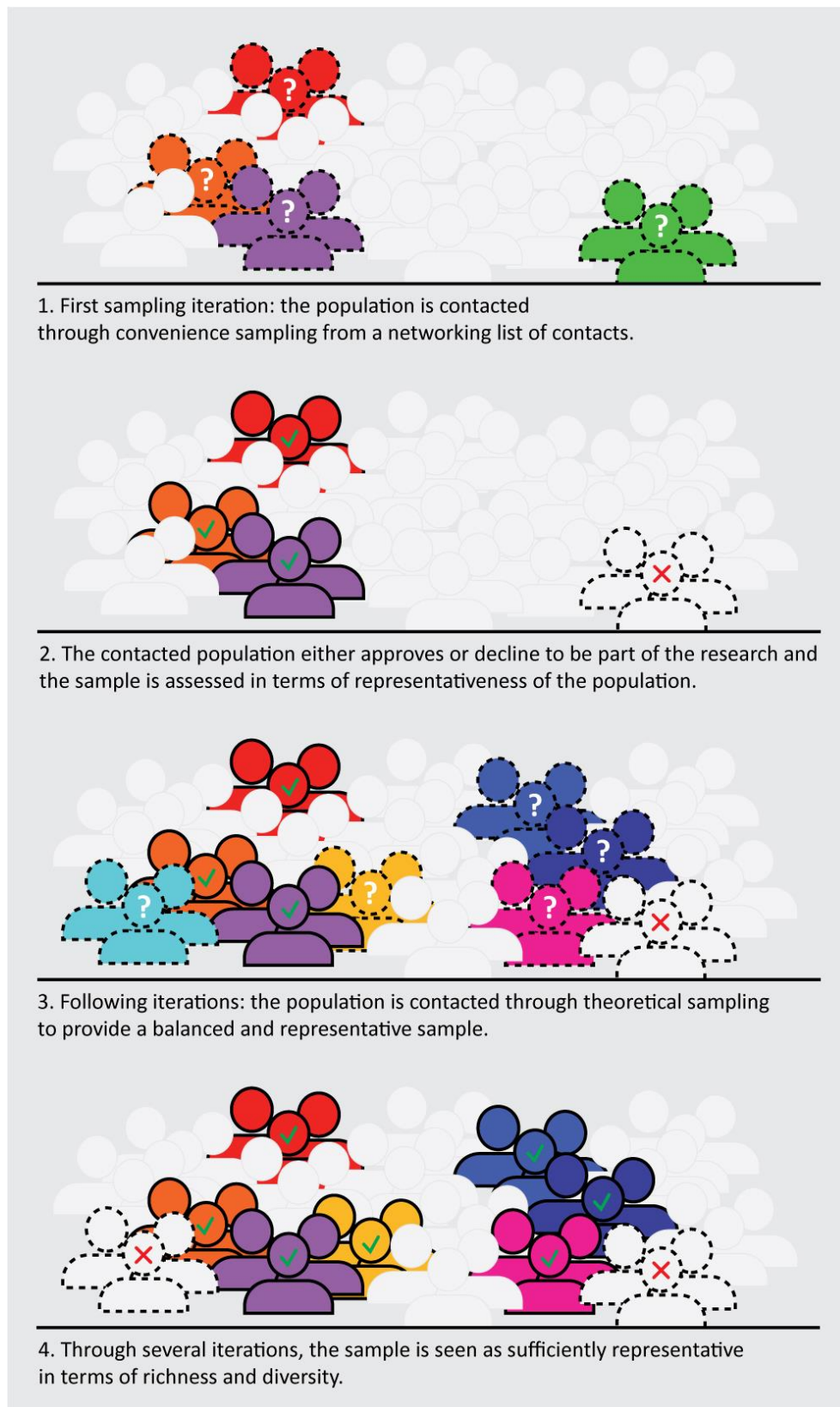


Figure 3.2 – The sampling activity (original work).

During the sampling activity, the researcher contacted and met numerous product designers, managing directors, product design consultants, product development managers, etc. While most were first approached during the sampling activity of the research, some of the potential participants were contacts met prior to the research, through work experience in the industry and previous networking activities. Certain participants were met by attending academic conferences and professional networking events centred on Product Design, Innovation or Eco Design; especially through the government-funded organisations Envirowise (now replaced by WRAP) and Knowledge Transfer Networks (now under Innovate UK). Others were contacted through common acquaintances: university staff and other direct industry contacts.

During this sampling activity, an important group of potential participants emerged through an independent research project managed by the researcher's university and funded by the government. This project aimed to help British companies implement Eco Design practices and the funding the companies received constituted of the support from an external team of Eco Design and Product Design research consultants. The researcher was not involved in the project itself, and was allowed to get in contact with the participating companies. This opportunity brought forward specific methodological considerations that are discussed in Section 5.1 - Data Collection.

An observable trend appeared during this activity regarding the likeliness of contacts to engage in research activities. The direct contacts generally responded positively to being asked to take part in the research. But the more indirectly linked the contacts, the fewer the chances of a positive response occurred. This was in effect a non-sampling error where potential units of analysis refused or were not able to participate in the research. At first, this established a certain problem of influence and bias regarding the selection of the sample, and there were pragmatically no other ways (in terms of leverage) to get the respondents to agree to take part. Due to this context of opportunity, the research first used a convenience sampling to develop a balanced representative sampling, through what could be called networking iterations (figure 3.2 - 1). The first iteration was purely convenient and to some extent random, getting in contact with direct and indirect contacts. Subsequent iterations were less so, and seek to involve contacts

that would balance the sampling to a representative population, using a theoretical sampling approach; filling gaps in the sample and providing richness and relevancy to the research (figure 3.2 - 3). It is believed that this was achieved, making the best use of time and opportunity; and that this representative sample also achieved a satisfactory level of richness and interconnectivity of data for future generalisation of results.

Unit of Analysis

“It is not always easy to distinguish whether an investigation is of one kind more than another. [But] it is important to be clear in your own mind what your unit of analysis is.” (Bryman, 2008, p.54)

Following the decisions made in the previous sections regarding the research population and sample, the unit of analysis is now considered. As presented in figure 3.1, the collection of all potential units of analysis constitutes the population, while the units of analysis to be investigated constitute the sample (an acceptable proportion of the population). The unit of analysis is the smallest common denominator of the research.

Here, this denominator represents the observations, accounts and other data collected from one participant in the design process. There may be one or more types of data, this data may be collected once or numerous times, but the whole ensemble of the collected data on a participant remains the data of one unit of analysis. The data from a unit of analysis may likely contain references to the case he/she is part of, but it remains the data of that one unit of analysis. Only direct accounts should be taken into consideration, and the accounts of one person on the activities of another should not be represented as a separate unit of analysis. In all, the unit of analysis is not to be confused with the case he/she is part of (the organisation or project where the data is collected). While data from an organisation or project may possess common meaningful connections to analyse, each unit brings their own personal view and piece to the jigsaw puzzle of the picture to be depicted.

Finally, the unit of analysis can be seen to be made of two parts: an object of observation (the participant itself) and a type of knowledge (the data the investigation will gather from each participant) (Verschuren, 2003). Both parts are determined by the aim of the research. Here, the research aims to gather knowledge from the Product Design industry. Therefore, the object of observation is to be made of participants in Product Design projects. Then, the type of knowledge the research seeks regards Eco Design practices. Therefore, the type of knowledge this research will gather regards the Eco Design related experiences, practices and perceptions from each participant.

3.3 Quality of the Research

To assert and guide the quality of the research, this section considers the concepts of internal validity, external validity (or generalizability) and reliability. The credibility of any research findings is significantly dependent upon how these aspects are dealt with and how supporting evidence is presented (Yin, 2003; Huberman and Miles, 2002; Robson, 2002).

Internal validity refers to how accurately the research findings represent the investigated setting (Silverman, 2006). Documenting every step of the research provides assurance and understanding that the research is actually investigating what it claims to (Arksey and Knight, 1999). But a crucial element to reach internal validity is to attain results through different sources and or methods. A multi-method approach can be used in order to triangulate the findings, reaching the same conclusions through different methods. Another way to make sure the obtained results are trustworthy is to reach the same conclusion over and over. This is when the data is collected from different sources (or perspectives) and reach the same results, achieving saturation of data and therefore internal validity. The depth of the investigation needs to allow to reach such levels of data saturation, while the breadth of the investigation needs to allow for results to reoccur across different

units of analysis and cases to reach saturation across the investigated sample. On the other hand, external validity (or generalizability) asks whether the findings of the research are valid across a larger setting than the investigated sample. Although generalising results to a wider setting is not a requirement for the research to be valid in itself; if the research is to claim external validity, its sample needs to be sufficiently representative of a wider population (see section 3.2). Reliability, closely related to replicability, is concerned with whether the results of a research are replicable (Bryman, 2008). To address this concern, the research needs to provide clear and detailed information on how the results were obtained (presented in the research chapters 4, 5 and 6). Along the next sections, the research makes choices regarding its methodology, keeping in mind these three important concepts. These are also discussed in regards to the methodology choice made and summarised in the last section.

3.4 Research Design

“A research design provides a framework for the collection and analysis of data. A choice of research design reflects decisions about the priority being given to a range of dimensions of the research process.” (Bryman, 2008, p.31)

For a qualitative research strategy, there are several useable research designs. Building on the choices defined in the previous sections and on the research designs described in the previous literature review chapter; this section presents potential research designs and the argument for the selected one. Distinction between the different research designs is sometimes unclear and each research can incorporate elements from different designs in order to best suit the enquiry. However, literature on the subject offers categories such as the ones by Bryman (2008) and used for argument in the following sections (Table 3.2).

Research Design	Qualitative Research Strategy, Typical Form
Cross-sectional	Qualitative interviews or focus groups at a single point in time. Qualitative content analysis of a set of documents relating to different time periods
Longitudinal	Ethnographic research over a long period, qualitative interviewing on more than one occasion, or qualitative content analysis of documents relating to different time periods. [...] when there is a concern to map change.
Case Study	The intensive study by ethnography or qualitative interviewing of a single case, which may be an organization, life, family, or community.
Comparative	Ethnographic or qualitative interview research on two or more cases.

Table 3.2 – Research design (Bryman, 2008, p.62) (adapted).

Longitudinal Design(s)

Defining longitudinal design, Bryman explains: *“With a longitudinal design a sample is surveyed and is surveyed again on at least one further occasion.”* And *“Because of the time and cost involved, it is a relatively little-used design in social research.”* (2008, p.49). This type of design aims to look for changes over a long period of time in a certain social setting and to understand causal influences over time. However, the present research is concerned with the state of current Eco Design. Although an understanding of the evolution of Eco Design implementation along an extended period of time could bring great insight to the discipline, the present research does not allow time for such collection of data. Therefore, this research design cannot be considered.

Case Study Design

Case study design, usually inductive, involves the in-depth analysis of either a single case or a few cases for comparison (Eisenhardt, 1989). A case can be a location, a community or an organisation and that specificity is the main concern (Bryman, 2008). Single cases makes generalisation unattainable. Case study design can be descriptive, exploratory or explanatory (Keddie, 2006). However, as Bryman

(2008) mentions, a case study is the “detailed intensive study of a single case”, stressing the importance of it being intensive. It is not to be confused with cross-sectional design which can have case study elements and vice versa. This makes it important to determine the main concern of the research: the case itself (and internal patterns) for a case study design or the patterns across the cases for a sectional design. There can be multiple-case study designs, but even then, the focus is on each of the cases themselves and their intensive examination of the setting. The addition of cases helps improve theory building by bringing together data from different settings, but if the focus is on theory building and gathering data across cases, then cross-sectional cases are more appropriate. The present research aims to gather data from as many cases as possible and although it is interested in the internal working of Eco Design in these cases, it primarily aims to find out what is happening across the British Product Design industry. Therefore, this design may not be appropriate.

Comparative Design

"[Comparative] design entails studying contrasting cases using more or less identical methods. It embodies the logic of comparison in that it implies that we can understand social phenomena better when they are compared in relation to two or more meaningfully contrasting cases or situations." (Bryman, 2008, p.58)

This logic of exploring and identifying meaningful patterns of social constructs through the comparison of two or more cases links comparative design to the multiple-case study design mentioned in the previous section. They are also similar in that they each usually use cross sectional design as a ‘sub-’ research approach within each case studied. Furthermore, comparative design can also use cross sectional qualities when the different social groups from the same case context are compared at the same point in time (Keddie, 2006). Bryman (2008, p.60) summarises this point: *"The comparative design is essentially two or more cross-sectional studies carried out at more or less the same point in time. The comparative design can also be applied in relation to a qualitative research strategy. When this occurs, it takes the form of a multiple-case study"*.

These similarities between cross-sectional, multiple-case study and comparative designs confirm Bryman's (2008) earlier point that research designs can be difficult to distinguish, especially as each research can incorporate elements from different research designs in order to best suit their enquiry. However, what makes a design valid on its own is its individual emphasis. In comparative design, albeit where there are similarities with other designs, the emphasis is on comparison. It is what defines the design and what makes it relevant and powerful to use for the researcher (Bryman, 2008).

One of the main strengths of the comparative approach is that it can offer better grounds for theory building by validating the existence of patterns across cases. Indeed, *"The key to the 'comparative design' is its ability to allow the distinguishing characteristics of two or more cases to act as a springboard for theoretical reflections about contrasting findings."* (Bryman, 2008, p.61).

Cross-Sectional Design

A cross-sectional design (or survey design) is a research design that on one hand, typically uses much more than one case, and on the other collects the data at a single point in time with the aim to look for patterns of association (Bryman, 2008). This type of research design employs interviews, focus groups or document analysis as a research method. The main strength of a cross-sectional design is the use of multiple cases to gauge variations between cases. The more cases, the stronger the analysis and case for generalisation – depending on the quality of the data and analysis. While the design generally makes use of preselected variables that require a quantitative approach; a version of the design uses qualitative survey aspects that could fit the need of this research. This design may not be best suited to explore the Eco Design landscape since it focuses on the variations of findings; but it could be used to confirm findings from a former exploration stage. Cross-sectional design also requires collecting all data from all cases at a single point in time so that time does not become a variable itself. This is an aspect that could also fit well within this research, if the data gathering stage is concentrated within a short time-scale. In all, the element of multiple cases studied at one time as well as

the use of interviews fits well the research need to survey and identify the variations of Eco Design implementation.

Summary

In light of this information, two designs emerge with great potential to fulfil the research aim of this present research.

First, in order to explore the current state of Eco Design, there is a need for a research design that allows to identify and demonstrate the presence of certain themes and factors in Eco Design implementation. While a (single) case study design could offer great depth of data and analysis, the design would significantly reduce chances of external validity (generalizability). In the same way, a longitudinal design would give great depth of knowledge about a specific setting, but would not allow to develop an understanding of the overall industry. A longitudinal setting would also require collecting data over a period of time that may be too demanding within the timelines of this research. To first explore Eco Design, the research needs a design that allows for the gathering of data across a reasonably large sample (higher than one case) to allow for enough reliability; yet with enough depth of investigation to explore the social constructs of Eco Design and firmly identify themes and factors in Eco Design implementation. A comparative design would therefore fit this aspect of the research needs, by exploring in depth a few cases and comparing findings between them for greater reliability. As a result, the sample used for this stage of research will consist of four cases from the government-funded project presented in Section 3.2 – Research Sample.

The present research is also concerned with the generalizability of findings, and therefore need to gather data across a large sample of the population. The use of a low number of cases in a comparative design would not be helpful in this aspect. However, using a cross-sectional design as a second stage of research could help confirm and corroborate the themes and factors identified during a first explorative stage of research. Because it can handle multiple cases, a cross-sectional design would allow the research to strengthen the basis for

generalizability. Moreover, because the design's emphasis is on variations and understanding what differences lie across cases; it would allow for the identification of the variations in themes and factors in Eco Design implementation. Here, the researcher will use a mix of all potential sampling opportunity (described in Section 3.2 - Research Sample) to gather and develop a greater number of cases.

Therefore, this research will be using two research designs. A first explorative stage of research will use a comparative design with a small number of cases. This will allow to explore the variations in depth of Eco Design implementation across the British Product Design industry. Then, a second stage of research will use a cross-sectional design. This stage will allow to corroborate the findings that emerged in the first stage using a larger number of cases, thus allowing for greater generalizability.

3.5 Research Methods

"A research method is simply a technique for collecting data." (Bryman, 2008, p.31).

Continuing to build on the choices elaborated in the previous sections, this section presents the research methods that were considered and those that were consequently selected to implement the research design.

Research methods are used to collect data during the research process. Continuing from the selection of a comparative research design followed by a cross-sectional design in the previous section; the section below presents the research methods that could fit either of both of these research designs. These methods are: ethnography and participant observation, interviewing, focus groups, documents, and action research.

Ethnography and Participant Observation

Ethnography and participant observation are two similar types of research methods whereby the researcher integrates a research setting to look at the meanings of the social life of a group. This can range from unobtrusive observation to active participation and requires an everyday involvement in the research setting for an extended period of time. This immersion into a social setting allows for in-depth data collection. It can also provide extensive data on a relatively narrow area of observation (or case). Repeated across cases, these methods can support in-depth insights, but they are highly time-intensive. And unless repeated across multiple cases, the derived theories only apply to the researched social setting (Hobbs, 2006; Coffey, 2006). These methods would allow collecting the range of data the research needs to. However, the methods used for this research need to take in account the limited amount of time companies may have, and this design would likely prove to be impossible to implement in practice, especially across multiple cases.

Focus Group

The focus group method involves group interviews by the researcher on chosen topics. This is most effective when participants are interested in the topic. Participants can reflect as a group on their experiences and perceptions and could provide rich findings. However, focus groups are difficult to manage; they require the ability to engage a whole group, sensitively restrict overly vocal participants and motivate quieter ones. Because the study is interested in views on personal issues participants encounter during the design process; the use of groups could limit the openness of the responses and therefore provide an incomplete image of the cases. Concurrently, Morgan mentions: *“Individual rather than group interviews would be preferable when there is a need for greater depth and detail about personal experiences or beliefs, because one-on-one conversations allow more time to generate richer narrative”* (Morgan, 2006, p.122). The present research is interested in depicting a rich, but also personal picture of Eco Design. Personal accounts can give more insights on why Eco Design is or is not implemented within

a social setting, and what are the factors each member of a case thinks is affecting the implementation of Eco Design.

Documents and Content Analysis

The use of archival sources, written and visual documentation allow for data to be collected about a specific social setting or case. Content analysis of existing documentation can provide rich data from multiple sources and mediums (Krippendorff, 2012). In historical research, this method can gather a great quality of data through personal accounts (for example, diaries). However, in the case of the Product Design industry, there is very little personal data recorded and kept that could provide personal insights. Design briefs would be difficult to access because an agreement would have to be made with each party (e.g.: clients and design team) for each design project. Also, a focus on documentation, design briefs, and therefore artefacts would better suit a deductive and quantifiable approach. The (Eco Design) comparison of the different briefs, designs and artefacts would require the use of quantitative metrics. This would need the use of tools such as Life Cycle Analysis with extensive amounts of quantifiable data. Because this research is looking for personal experiences, views and opinions and that such information is qualitative in nature and would not be featured within written documentation; this method would not be appropriate.

Action Research

"...can be defined as an approach in which the action researcher and members of a social setting collaborate in the diagnosis of a problem and in the development of a solution based on the diagnosis." (Bryman, 2008, p.382). This research method, like ethnography and participant observation, allows the gathering of in depth, rich amounts of data; but only from within a single social setting. Generalization is almost non-existent in this case, and it is not the purpose of such method. Here the emphasis is on the understanding of a social setting and on the causal effects of changes implemented by the social setting and the action researcher. Action Research would be a great method to test social change theories

and/or try to implement findings from one social setting into another. Although those aspects could provide great insight to the Eco Design discipline, such method would only bring another narrow/personal account of a single social setting; providing no further understanding of the state of the art of Eco design as a whole.

Interviewing

Interviewing involves asking a series of questions, through a meeting or dialogue with personal and social interaction. Different types of interview techniques exist ranging from unstructured to structured formats. Unstructured interviews offer rich grounded data but are very time consuming for gathering and analysing the data. More structured formats reduce time and difficulty but the data may be incomplete (by not asking the right questions) or biased (by structuring responses). In most cases, the availability of the researched group often asks for trade-offs between what is ideal and what is feasible (Davies, 2006); and in turn directs the type of interviewing technique that can be employed in the research.

In structured interviews, *"The aim is for all interviewees to be given exactly the same context of questioning [...] to ensure that interviewees' replies can be aggregated"* (Bryman, 2008, p.193). This format is helpful when there is a need to compare and analyse replies against one another. It is usually used in quantitative research strategies, especially in quantitative survey designs. However, in the present research, the emphasis is explorative and structured interviews may hinder the discovery of unexpected areas of the particularities of a social setting.

However, *"In qualitative interviewing, there is much greater interest in the interviewees' point of view [...], 'rambling' or going off at tangents is often encouraged - it gives insight into what the interviewee sees as relevant and important [...], interviewers can depart significantly from any schedule or guide that is being used. They can ask new questions that follow interviewees' replies and can vary the order and even the wording of questions. [...] As a result, qualitative interviewing tends to be flexible, responding to the direction in which interviewees take the interview and perhaps adjusting the emphases in the research as a result of significant issues that emerge in the course of interviews"* (Bryman, 2008, p.437).

Qualitative interviewing techniques include semi-structured interviewing, unstructured interviewing as well as what can be considered as variations between the two. In unstructured interviewing, researchers only use a list of topics to direct their interviews. The interviews are largely informal and the topics discussed between cases may vary. One of the main weaknesses of this technique is its lack of internal replicability (the difficulty for the researcher to replicate the same type of interview); but also its lack of external replicability (the difficulty for another researcher to conduct the same research). This is due to the lack of a clear agenda, of any question list or even interview guide. As a consequence, this technique may be restrictive across multiple cases. It may not allow for an understanding of how certain aspects of a social setting are repeated across cases if the information is not more methodically gathered. Without some sort of guide or interview agenda, data that could contribute to create a rich picture may not have the chance to even be recorded. Therefore, this technique may not be best suited to the present research and the choice of a cross-sectional and comparative design.

On the other hand, semi-structured interviews provide the possibility to create a richer image of social settings while keeping a structure to the interviewing process. The technique allows for the gathering of data on independent and personal accounts where each participant offers an individual view of their social setting. Although the emphasis of the research is based on exploring and identifying social patterns rather than providing grounds for structured comparison of variables; the technique allows for the comparison of participants' views, looking at company, sector or job type as variables and using the same interview guide across all cases (Bryman, 2008). These accounts are only guided by the introduction of these topics of conservation and open-ended questions which allow the participant more freedom to express views (Bryman, 2008).

Summary

As a result, the present research will opt to use semi-structured interviews in order to gather data on the participants' experiences, practices and perceptions of Eco Design, using the same interview guide across the cases. As mentioned above, semi-structured interviewing is a technique that will pragmatically provide

sufficient internal validity, providing multiple accounts of the same event. Reliability and replicability will be attained by methodically documenting the research process and providing an interview guide for use across the cases of this research but also for other researchers to follow (presented in the research chapters 4, 5 and 6). However, this replicability will of course be limited to the fact that all data obtained through this research will be linked to a specific point in time.

Conclusion

This research will employ a qualitative and inductive strategy. As mentioned in this chapter, the research is concerned with participants in Eco Design projects. Therefore, the population will be bound to people involved in Product Design and will be limited geographically to the United Kingdom. This will include product designers, product design managers, Eco Design consultants and managing directors; both at in-house design teams and design consultancies. The research will select a sample based on convenience and theoretical sampling activities to reach the desired level of representativeness. Each unit of analysis will represent a participant's accounts of experiences, practices and perceptions of Eco Design related activities.

Two stages of research will be used to perform the investigation. First, an explorative stage of research will focus on a depth of analysis to explore Eco Design in Product Design and unearth themes and factors linked to implementation. Then, a corroborative stage of research will focus on a breadth of analysis to corroborate the findings from the previous stage of research and to identify variances in the occurrence of Eco Design across a large number of cases. Also, in order to test the interviewing research method and to experience hands-on the field of research, a pilot study will take place prior to the two stages of research (presented in the following chapter 4).

In the explorative research stage (using a comparative design), semi-structured interviews will be carried out with a low number of cases. This stage will

aim to interview at least three participants per case to provide different perspectives from within each case, and when possible, interview each participant on several occasions to reach greater internal validity. It will be important to gather information from different perspectives in each case, through the interview of different members, in order to identify data saturation (i.e.: when the same findings re-emerge several times, confirming themselves) within each case and to confront the views of each individual. The same concerns will apply to the lengths of the interviews, which should last long enough for findings to reoccur and provide data saturation.

Then, the corroborative research stage will use a cross-sectional design. In order to achieve the research aim, this second stage of the research will focus on data saturation and confirm findings from the previous stage of the research. Semi-structured interviews will be used as a main method of data gathering and these will be carried out on a maximum of 10 cases. Pagell and Wu (2009) explain that in most cases, data saturation happens from 3 to 11 cases. The authors also explain that from around 7 cases, a person reaches the maximum limit of how much diversity of information they can mentally process. The reasoning for this number of cases also relates to an aspiration for richness that needs to be balanced with the constraints of the research program (i.e.: a PhD); but also to satisfy an important aspect of the methodology: reaching external validity (or generalizability). This will be achieved through the combination of the devised stages of research, selected research designs, methods, and representativeness of the sample.

Methodological matters regarding the analysis of the data are presented in the research chapters 4, 5 and 6.

The Research Structure

The investigation activities and consequent data analysis of this research are presented in the following three chapters (see figure 3.3). Chapter 2 provided an understanding of the current knowledge of Eco Design implementation in industry, while chapter 3 presented the different methodological options and choices for the undertaking of this research.

*In turn, chapter 4 provides an overview of the activities undertaken during an **initial pilot study**. The initial pilot study aimed at exploring, testing, and fine-tuning the divided methodology with regard to the population sample, but also providing initial ideas and inferences on potential themes linked to Eco Design implementation. Chapter 4 presents this information as well as initial knowledge and experience gathered on conducting research in the Product Design field.*

*Using this knowledge, chapter 5 presents a revised methodology and the **explorative stage of research**, exploring and unearthing recurrent themes relating to Eco Design and its implementation. This was done through the use of a **comparative case study design**, using **semi-structured interviews on four design project cases** (each made of several organisations). Chapter 5 first provides a set of methodological revisions before presenting a thematic analysis of the cases through the use of four individual narratives. This stage of research provides an initial set of themes to Eco Design and its implementation. These are discussed through a comparative analysis of the occurrence of each of the themes across the cases.*

*The **corroboration stage of research** presented in chapter 6 provides validation through the use of a **cross-sectional case study design**, using **semi-structured interviews across nine organisations** (each consulted on several projects). Chapter 6 presents an overview of each of the cases, before reviewing the presence of each of the themes uncovered in the previous stage of research through a comparative analysis. The themes are adjusted, modified and adapted to the new findings, providing a revised and comprehensive list of themes relating to Eco Design implementation.*

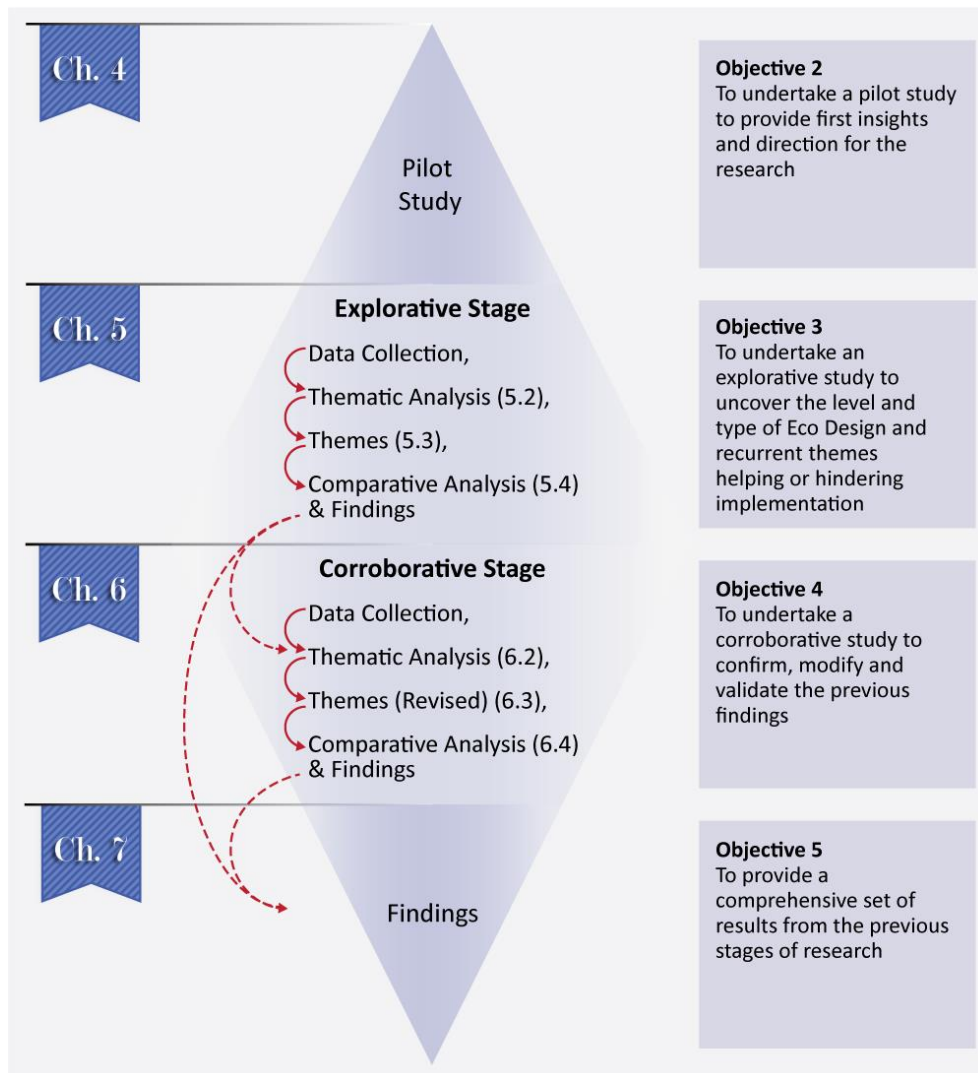


Figure 3.3 – The research structure (original work).

Chapter 4 - Pilot Study

This first research chapter presents the undertaking and findings from the initial pilot study. This chapter first introduces the pilot study, its aim and objectives. It then presents each of the seven small cases and discusses the emergence of initial inferences on potential themes relating to the implementation of Eco Design. Finally, this chapter closes by outlining the learning achieved, in terms of methodological directions and concerns for the subsequent stages of research, and in terms of initial findings.

Introduction

The methodology chapter defined the approach and methods selected for conducting this research. It was decided to use two types of case study approaches (comparative and cross-sectional) for two separate research stages. In order to better conduct these stages of research, it was decided to first conduct a pilot study. The aim of this initial study was two-fold. It first allowed to ‘test the water’ in terms of the devised methodology, to learn from and be able to adjust the methodology for the main stages of the research. Secondly, it allowed the gathering of initial inferences on potential themes to the implementation of Eco Design. For this pilot study, 14 participants were interviewed across seven company cases. The cases were selected using a purely convenient sample because the aim was to test the methodology rather than seek validity. The following section presents those methodological considerations as well as a thematic analysis, using short coded narratives from these seven small cases.

4.1 Thematic Analysis

The following section presents the findings from seven small case studies undertaken as part of a pilot study. These cases are presented in turns, in the form of short narratives. They are numbered and take an alias to keep the anonymity of the organisations and participants. The data presented below introduces an illustrative coding also used in the following research chapters. In the shape of right-aligned block arrows, these codes represent and outline certain aspects of conversations, opinions, approaches, which will later on be collated and developed into themes (see Section 5.1 for a description of this process).

01 – Silver

Less than 50 employees, five interviewees

‘Silver’ develops and manufactures signage for large companies and has over 50 years of experience designing, manufacturing, installing and maintaining a wide range of external and internal signs. The manufacturing facilities consist of an area for prototyping, a set of machines for cutting and perforating, an area for welding and sanding, a powder coating machine, equipment for spray painting (complying with strict environmental regulations on emissions), an area for internal fixing, a graphics area with vinyl printers and a multi-surface flat printer. While the company had been lagging behind regarding environmental regulations; it recently invested significantly in the area. The Manufacturing Engineering Manager, alongside his job, obtained the previous year a Masters in Lean Manufacturing from Coventry University. He joined ‘Silver’ around 18 months ago. The engineering team uses ‘GaBi’, software for product and process sustainability analysis. The interviewed Engineer is focusing on projects’ Environmental Impacts when the client specifies it as a requirement in the brief. However, they do not include environmental design techniques within their practice. The team works to reduce costs on material (and therefore resource use) whenever possible, but it

Legislation

Green Champion

Design Process

seems they will not interfere on the actual design image of the product. The New Business Sales Executive presented the different possibilities that offer the new techniques in printing that 'Silver' has invested into. They developed a company to deal with the graphic side of their product as well as to offer graphic design services. All of the interviewees expressed that the design process running between receiving the brief to the actual manufacture of the product is made more difficult due to a lack of communication and insufficient partnerships between the involved parties (clients and suppliers). Back and forth steps between the different actors of the process are common, whether it is to make changes to the design, its feasibility, or to the brief. The environmental side, when considered, is pushed forward by the client. However, there seems to be a primary lack of Eco-Design knowledge from both 'Silver' and its clients.

*Organisation
Collaboration*

*Environmental
Objectives*

02 – Titanium

Less than 50 employees, two interviewees

'Titanium' designs retail displays and outsources their manufacturing needs. This is a small company of less than 50 employees. Interviews were conducted with the product designer and a product design intern. It emerged that environmental performance or sustainability aspects were not usually in their clients' brief. However, in regards to the development of their own lines of products, they believe there was a business case to develop a greener alternative to their retail displays embedding electronics and displays. Even with this drive to develop greener products, there seemed to be little knowledge of greener materials or designs and no knowledge of Eco-tools or Eco Design principles. The product designer conveyed a personal interest for Eco Design which seemed to be met higher up in the organisation through marketing objectives and having the possibility to offer 'green' products.

*Environmental
Objectives*

*Environmentally
Engaged*

*Eco Design
Knowledge*

Eco for Marketing

03 – Tin

Two employees, two interviewees

‘Tin’ is a small and newly formed Eco Design consultancy that helps lower the environmental impacts of their clients’ products. The two founders that constituted the whole company were interviewed, but it remained difficult to understand how their service was delivered. They possessed years of experience in the field of Product Development from previous roles but only had recent Eco Design experience. The consultants were not technically informed but were experienced in terms of overall product development and product launch. Unfortunately, very little actually came out of this case, due to a lack of projects to discuss and potentially a lack of openness.

*Environmentally
Engaged*

04 – Mercury

Over 10 employees, two interviewees

‘Mercury’ is an Eco Design consultancy with years of experience and work across the UK. They provide help to all types of businesses on reducing their environmental impacts and on becoming more efficient (i.e.: saving money and lowering environmental impacts, in that order). During interviews and several meetings, both founders were seen to be aware of Eco Design principles, Eco-tools and environmental strategies. They believed there was loads of ‘low hanging fruits’ (or easy-wins) in terms of increasing environmental performance and decreasing costs. However, they also expressed companies were usually not interested in any mid or long-term investments on environmental strategies. Quick return on investment was paramount to most projects they were consulting on.

Views

Used Approaches

*Environmentally
Engaged*

05 – Lead

Over 250 employees, one interviewee

Only one interview was made for this case. Finding interview candidates and access to the company employees was difficult. The interviewee was not a product designer but a project manager. He had little technical knowledge but was able to explain how important environmental aspects had become in the last few years. Although the interviewee (as well as the company's work and website) promoted their investment in environmentally friendlier designs, none of the persons contacted were available for an interview. This highlighted the difficulties in finding both cases and participants. At the time, it was understood this could bring drawbacks to the next research stages.

Views

*Environmentally
Engaged*

06 – Platinum

Over 250 employees, one interviewee

This case was made of one interview with an environmental advisor of a large, high profile manufacturer of building materials. In this company, environmental credentials were part of the main selling points of the products they developed. Reducing levels of toxicity and materials used while ensuring fair conditions for materials extraction and manufacturing were some of the priorities the company put forward. The interviewee felt generally very invested both technically and on a personal level. However, the interviewee provided little knowledge on the workings of Eco Design in his company, and steered the conversation away from details regarding his practice. This is also a point and limitation to the methodology used for this research, namely: the lack of access to company knowledge, even in an anonymous setting.

Eco for Marketing

07 – Iron

Over 250 employees, one interviewee

‘Iron’ is a multinational company, supplier of energy. The person interviewed was in charge of Corporate Social Responsibility for the UK and was first met at a networking event and training on environmental strategies – while networking for potential research cases. The interviewee was in charge of projects aimed to reduce the overall impact of the company. It became clear that the size of the company was hindering their communication channels when it was found that one of the projects she had worked on during the last year (developing environmental self-assessments for their suppliers) had already been developed by another branch of the company in a different country.

*Problems of
Communication*

*Environmentally
Engaged*

Conclusion

This initial Pilot Study helped the research in understanding the challenges associated with finding cases and handling the interview process. Companies are understandably wary of sharing inside knowledge and employees find it difficult to discuss the organisation of their company, due to a lack of trust in the research and its anonymity. This makes it difficult to find volunteering participants and organisations, and to develop cases with multiple interviewees and interviews. The information gathered in each of the cases 05, 06 and 07 only came from a single source and at a single point in time. These cases therefore lack validity in terms of knowledge gathered specific to the case and do not allow for generalizability across the cases of this Pilot Study.

As a result, this research exercise has helped understand the importance of building cases with more participants, to understand and be able to cross-reference views and practices through different individual perspectives and experiences.

With regard to initial findings, the cases were not strong enough to be adamant that any of the aspects discussed could be part of a larger theme on Eco Design implementation. However, it emerged that there seemed to be a pronounced lack of communication between product designers, managers and clients, particularly regarding Eco Design aspects. It also emerged that Eco Design practices seemed mostly limited to cost-reduction exercises. These aspects were however taken into account for the subsequent stages of research, and are explored and discussed further in the following chapters.

Chapter 5 - Exploration Stage

This chapter is the second of three research chapters. Following on from the knowledge gathered during the Initial Pilot Study presented in the previous chapter; this chapter presents the undertaking and findings of the explorative research stage. It first provides a set of methodological revisions and an overview of the data analysis method (Section 5.1). Then, it presents the coding of themes through case narratives (Section 5.2) that help define the recurrent themes (Section 5.3), which are developed through a comparative thematic analysis (Section 5.4). The research practice and its challenges are also discussed as a part of this chapter, including a reflection and critique of the methodology.

Introduction

The methodology chapter discussed various approaches and methods that could potentially fit the research needs. With consideration and learning from the literature review and from the pilot study, it was decided to undertake an Explorative Stage of study to explore, define and identify common and recurrent themes in the implementation of Eco Design practices in the British product design industry. This data was captured through semi-structured interviews on four different design project cases, each made of several organisations. The four cases made up a total of 30 interviews across 23 interviewees. The data for each case was transcribed, coded and analysed in isolation and in comparison with the other cases (as described in details in the following section). The process and findings to these activities are presented below.

5.1 Methodology

This chapter presents the analysis of the data collected on four cases and provides narratives; giving context to the challenges faced when implementing Eco Design approaches and describing the experiences lived by the participants. This information was collected through semi-structured interviews, across several months. The section below presents the methodological context that formed this stage of research.

Data Collection

This stage of data collection followed the sampling activity described in section 3.2, Research Sample. In terms of methodology, the researcher had to adapt to the different needs and availabilities of the participants. Interviews were undertaken with designers, engineers, environmental consultants, project managers, production managers and managing directors when available. The data gathered mainly focused on their on-going Eco Design related projects, but also concentrated on their more general Eco Design activities.

This stage of research enabled the gathering of a great amount of data. Through semi-structured interviews (usually around one hour in length); each interviewee provided a rich picture of their case through detailed accounts of their personal experience. These personal perspectives resulted from the different interviewees' backgrounds and positions in the company. The interviewees were asked to describe what was happening in their case in terms of Design Process and Eco Design activity. They were asked about their involvement in Eco Design, both in their role and in terms of personal development and interest. They were also asked about their company and personal views on the need and value of Eco Design.

The researcher guided the interviews through the introduction of broad themes (or topics) and open-ended questions, as advised by Bryman (2008), which allowed the participants more freedom to express their views. Each theme was

devised in consideration with the findings from the literature review on Eco Design implementation (Section 2.5): the described implementation phases (consideration, selection, implementation, use) and the types of factors affecting implementation (demand-time, awareness, process, knowledge, trust). These themes are inherently present in each case, whether they describe their presence (for example: Eco Design ‘Adoption’) or their absence (lack of Eco Design ‘Adoption’). These themes will help shape the analysis and develop connections with existing literature that use similarly framed themes. However, the analysis process following the interviewing stage will also look for any reoccurring findings in specific areas that could form new and emerging themes. The initial themes as well as examples of their corresponding interviewing questions are presented in the table below:

Theme	Interviewing Guiding Questions
Opening questions - Describing the interviewee’s role and providing context for the following questions	<ul style="list-style-type: none"> - Could you talk to me about your role here? Do you have a defined title? - And do you have any other roles? - How long have you been in this role and company for? Were you in similar roles beforehand? - You mentioned the [medical sector] being a large part of your work, could you tell me more about this? - You discussed the use of a certain design process, could you elaborate on this aspect?
A. Views - On Eco Design as a discipline and a practice in industry.	<ul style="list-style-type: none"> - How are issues relating to the environment manifesting within the company? - Is Eco Design an important part of your work/role? - Do you feel your work/company should involve more Eco Design elements?
B. Objectives - How and whether Eco Design objectives are part of the design brief.	<ul style="list-style-type: none"> - Are there elements of Eco Design in the design briefs of the projects you work on? - Do your clients have requirements relating to environmental objectives? - Can you think of projects where there was an Eco Design related objective? Maybe in the brief? - In your experience, has the importance of the environment in design briefs changed over the years? How so?

C. Adoption - What Eco Design principles or approaches are considered in the design process.	<ul style="list-style-type: none"> - How are Eco Design related issues/objectives looked at within your projects? - Is there a set of principles, maybe an internal tool or set of directions that you/your team follows to integrate Eco Design principles?
D. Approaches - Eco Design approaches (incl. Eco-Tools) used in the design process.	<ul style="list-style-type: none"> - Do you have any kind of more or less set design process within your team/company? - What type of tools/software do you use within the design process? - Do you use any tools or specific approaches to work on Eco Design related matters? - I heard you (the company) had a library of materials? Is this something you use? Are there references to environmental matters within these resources? - You mentioned you had an ideas board. Does it include Eco Design elements? - You mentioned a lack of demand for Eco Design. If there was more demand, how would you see Eco Design being approached more systematically? - Do you think this is an area that will grow?
E. Knowledge - Designers and teams' knowledge of Eco Design and how the knowledge is developed.	<ul style="list-style-type: none"> - How do you get to hear about new materials, processes and ideas? - You mentioned you browsed websites and forums because of your personal interest in those subjects. But is gathering new knowledge part of your role? - Is there time set apart within your projects to gather knowledge? Are you expected to develop your knowledge? What are those expectations? - Would you say Eco Design information is harder to gather than for other segment of Design information (e.g.: user interface)?
F. Sustaining Implementation - How Eco Design implementation is sustained.	<ul style="list-style-type: none"> - How do you keep hold of new information, for example about new materials or processes? - Do you collect this knowledge centrally? Is it individually stored? - Are you aware of your colleagues' collection of knowledge? - Is there Eco Design related information, gathered during previous projects that would be available for you to look at?

Table 5.1 – Description of the interviewing themes and questions (original work).

The interview process provided a very large amount of data (interview recordings, interviewer's notes and interviewees' diagrams). It was exhilarating to hear so much about the design process and the Eco Design approaches experienced

by the participants. The most interesting type of observations was to uncover similarities in the struggles, drives and challenges that participants shared within and across cases. This was particularly interesting because it illustrated the potential of the research to provide new knowledge and understanding about Eco Design implementation by collating individuals' experiences. More and more data was acquired and data saturation naturally occurred across most participants and cases. This was a very important learning curve for the interviewer. Each interview provided more insight and experience as how to conduct the next interview and as to what questions to ask and how to ask them. And while the interview guiding questions remained similar, they evolved to be more open-ended and as little inferring as possible.

The interviews were generally quite informal. The participants were put at ease that none of the discussion would later be related to either the participant or the employer. However, some participants did not feel secure enough to express their personal ideas. They only used very short answers that lacked specific or personal details. But it seems that the longer the interview tended to last, the more open the interviewee would become. Another factor related to the setting in which the interview was taken. A few interviewees expressed anxiety that the walls were thin and may have 'ears'. Another type of 'holding-back' was noticed amongst directors and managers who seemed to be less inclined to express negative aspects. On the other hand, it seemed much easier for hierarchically lower staff to put blame on the company structure and/or sometimes directly on their managers. Non-managers also seemed much more emotional during the interviews. There was anger, frustration, excitement, crying, sighing, nervous laughing and eye rolling throughout. In contrast, company directors seemed much calmer and distant from the questions. Somehow, there was a certain feeling of truth coming more from staff than from managers. They were providing much more details and stories to contextualise their thoughts; whereas directors and managers seemed to prefer broad views with little focus on examples.

The aim of this Explorative Stage of research is to explore the themes relating to the implementation of Eco Design in the design process. Therefore, the research looked for stories and self-analysis from participants depicting their past and current experiences in Eco Design; and expected themes to emerge depicting

the level and type of Eco Design implementation as well as potential drivers and barriers. This stage of research was highly explorative. It only aimed to uncover and define the appearance of emerging themes. The following stage (depicted in Chapter 6) looks at whether these appear consistently across a larger sample of the population and to confirm their value. This is why this first stage aims to dig deeper within a smaller selection of cases, so to pick emerging themes out of the collected stories.

The research looked for around four to five cases where there would be a project with an Eco Design element included in the brief. Each case would have to be made of at least one company with several participants, but preferably more to get different external perspectives on the same 'stories'. Those would contain multiple interviews from the same participant in on-going projects and more data (or stories, experiences) could be collected later on and when possible (regarding the availability of the case). This was made possible through the access to an independent research project (introduced in Section 3.2 - Research Sample), funded by the government and managed by the university. The researcher was not involved in this funded project that had commenced before the timeline of the present research. Using this sampling avenue, the researcher gained access to a set of four cases. Each case was comprised of a company seeking help implementing Eco Design, as well as an external team of Eco Design and Product Design research consultants.

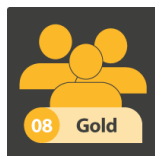
There were several strengths to using this set of cases. Using this funded project as a case selection pool helped find design projects with an Eco Design element; and since the researcher's university was part of the funded project, the selected cases were also more inclined to be approached and interviewed by the researcher. This configuration was also beneficial in terms of timelines. The design projects of each case were running to a specific and similar timeframe. This provided more security that the design projects' outcome would occur within the timeframe of the present research. It also gave more security that the projects would go through since they were funded. Each project involved several participants from different companies, teams, background and expertise. In each case, there was a main company (that had applied for the funding) with its own in-house design team and at least one environmental consultancy and a design

research unit attached to it. It is thought being able to interview within each case a diverse selection of participants, brought more richness of data to this stage of research.

However, this configuration also brought certain weaknesses to the research setting. The main companies were not engaged in their normal context of activities and the involvement of external consultants changed the way they operated their design process during the project. To overcome this, the interviews also focused on the participants' past experiences and more general Eco Design activities. Participants may also see the researcher's affiliation to the university (involved in the funded project) presenting a certain conflict of interest, and think the researcher may report back to the university. This could result in the participants being unable to open up and be truthful during interviews. To minimise this potential problem, the participants were put at ease; explaining that all data collected from the interviews were confidential and that the researcher was in no way involved in the funded research project.

To keep the anonymity of the participants in this thesis, each case and participant were given a number associated with a colour. This was devised to help distinguish rapidly and visually, along the analysis, the different cases and participants in both the text analysis and within the visualisations of the analysed data. Each case is numbered and given an alias, and each interviewee is given a four digit code, comprising of its case number, alias and its own (random) interviewee number. For example:

- Case 08 – Gold



- Interviewee 01 from case 08 – Gold



Thematic Analysis

30 interviews were undertaken across the four cases, typically lasting around one hour. This resulted in 28 hours of audio recording. These recordings

were transcribed then analysed along with the input gathered from the diagrams drawn by some of the participants and the notes taken during the interviews. The table below presents the method used to do so. Braun and Clarke (2006) suggest a set of six phases (adapted in the grey boxes of the table below) when undergoing a thematic analysis. The sections in between the phases presented by Braun and Clarke contextualise the process in regard to the present research.

Phase	Description of the Process
1. Familiarising yourself with your data	Transcribing data (if necessary), reading and rereading the data, noting down initial ideas
<p>The data was collected with a recording pen (Livescribe SmartPen) which linked any moment of the audio with the time at which notes were taken. This allowed the interviewer to take less notes and to instead, use keywords and simple marks to identify the most interesting moments. The interview felt therefore more like a conversation than an interrogation. The interviewees and the interviewer also kept much more eye contact. This difference was noticed, especially in comparison with the interview experience from the cases 01 to 07; where this recording device was not used.</p> <p>All interview recordings were transcribed in a shortened, paraphrased format. Notes (keywords and marks) were taken during the interviews to help find the moments that needed attention or were thought to represent hunches on potential themes. The process of undertaking the interviews, taking notes, listening to the recordings and especially the act of transcribing the recordings enabled the researcher to be best familiarised with the data.</p>	

2. Generating initial codes	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code
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After the transcription and familiarisation with the data, each transcript was looked at in parallel with the notes taken, to note down recurrences and interesting aspects relating to Eco Design and generally to the product design process. Potential remarkable stories were highlighted too, especially when developed by more than one participant in a certain case. From this phase of analysis emerged codes: keywords that synthesised certain aspects of conversations, certain opinions, approaches, etc.

3. Searching for themes	Collating codes into potential themes, gathering all data relevant to each potential theme
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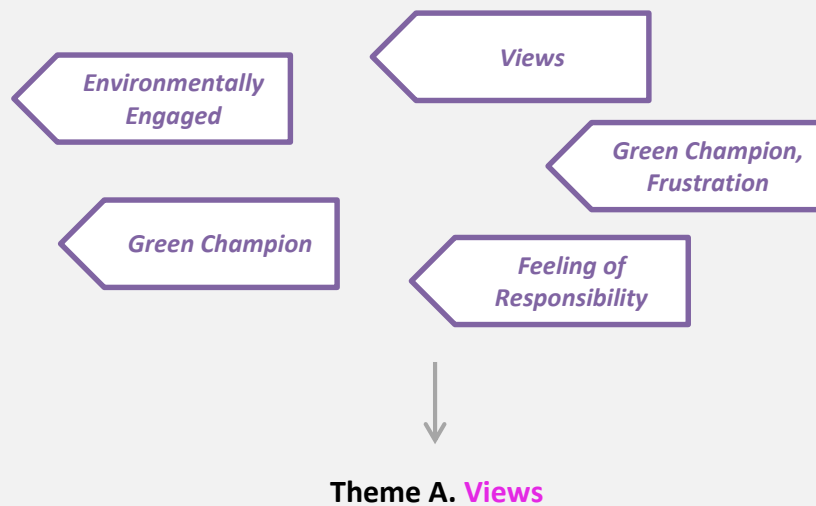


Figure 5.1 – Assembling codes into pre-set or emerging themes.

4. Reviewing themes	Checking if the themes work in relation to the coded extracts (phase 1) and the entire data set (phase 2), generating a thematic 'map' of the analysis
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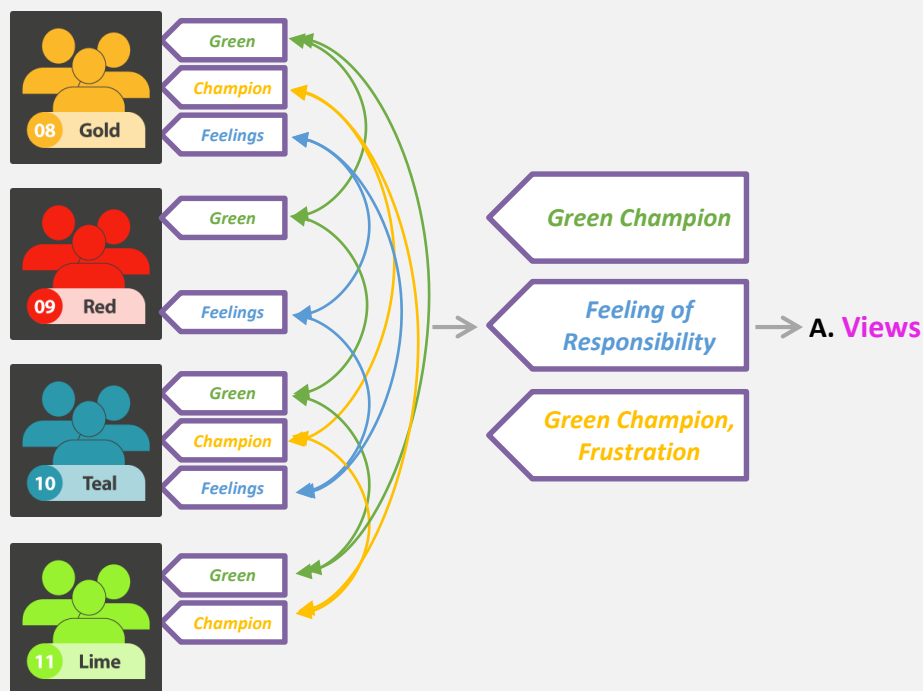


Figure 5.2 – Checking the themes correspond to the codes across all cases.

5. Defining and naming themes	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme
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Reading and rereading the analysis conducted so far, patterns of association between the codes were identified and the codes were merged into themes. Each theme was defined and assigned a letter to enable to go systematically through the transcripts and assign each theme to the relevant areas. The process of going through these three phases of analysis (3. Searching for themes; 4. Reviewing themes; 5. Defining and naming themes) was an iterative one. First, codes were generated across the transcripts. Then, themes emerged out of the codes; but more codes appeared and the themes were adapted to these new findings when bringing the data from all the different cases together.

6. Writing-up	The final opportunity for analysis. Selection of vivid compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.
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The writing (presented in section 5.2) was in itself a way to analyse, or confirm/double-check the work undertaken during the analysis. This was done through the use of narratives, providing accounts of the design process in each of the cases. The selection of which examples to present, which stories to highlight, in which order to compile the content, and especially how to relate the findings to the literature were also key parts of the analysis.

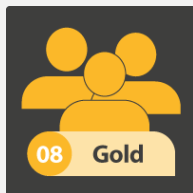
Table 5.2 – Phases of thematic analysis (adapted from Braun and Clarke, 2006).

Comparative Analysis

In the instance of a multiple case study design (such as in this research), Comparative Analysis helps to provide validity to the findings. The Comparative Analysis compares the findings of a study repeated in a systematic fashion across different cases. In this research, while the themes were teased out within each case independently during the thematic analysis (introduced above and presented in the following section); the themes were then combined into a representative, coherent set during the comparative analysis. This process and findings are presented in section 5.4 of this chapter.




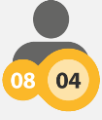

5.2 Thematic Analysis

This section introduces each of the four cases studied during the Explorative Stage of research and provides a narrative exploring and describing unfolding of events in design projects. A short background, as well as a description of the organisations involved and of the different participants is given below for each of the cases. This is then followed by narratives which provide coding of the data (through the use of right-aligned block arrows) to be collected into themes, presented and discussed in the following sections (Section 5.3 - The Themes, and Section 5.4 - Comparative Analysis).



The principal company in **08-Gold** is an SME, designing and manufacturing retail design units. Their main product is a standard modular unit which can be considered as a product-service system. They lease the use of the unit as a service rather than a one-off sale. This usually includes the installation, long-term maintenance and storage of the system when needed. This business approach is seen by the company as a more environmentally friendly approach to retail design where each module of the units can be reused, refurbished and recycled. This case also contains the interviewing of an external company that provided on an occasion environmental consultancy services to the SME.

The case consisted of 5 Participants and 7 Interviews.

	Graduate Product Designer Masters in Eco Design, Environmentally engaged
	Product Design Intern Low interest in Eco Design
	Product Design Manager Manager of 0801 and 0802
	One of the two company directors, Environmentally engaged
	Environmental Consultant External company, Only in contact with 0804

0801 was a young female, graduate product designer at the company. This was her first job out of university, after a Masters in Eco Design. This interviewee was the most environmentally engaged met across all the research stages. She was also very invested and emotional during the interviews in regards to the challenges she faced. “*Frustration*” was a word she used that could sum up her experience trying to implement Eco Design in her projects and across the company.

Environmentally Engaged

0801: *It's my passion, environmental stuff; therefore I do it in everything I do in life.*

0801 was both environmentally invested and knowledgeable. Her studies had given her the training in both Product Design and Eco Design from one of the top universities in the country. She had knowledge on Eco Design principles and approaches, as well as on certain Eco-tools.

Eco Design Knowledge

Adoption & Approaches

Interviewer: *Do you use any eco-tools?*

0803 (Design manager): **0801** *worked on it. But it didn't happen. It didn't fit with what we do. It would be more of a marketing tool rather than a tool for sustainable design. I don't think we have enough operations to warrant the use of it. A lot of it is common sense. It's more about making everybody aware of what we're doing, which is what 0801's role was.*

Beside her main role as Graduate Product Designer, she was in charge with implementing an environmental management system for the company (the **ISO 14001**). This work allowed her to gather knowledge on the different parts and operations of the company and to widen her skills and knowledge in environmental issues. Although she saw this activity as a good learning experience, she encountered frustration throughout. From her point of view, the ISO 14001 accreditation was mainly sought for marketing purposes. Interestingly, the company portrayed an environmentally aware and engaged image, but she felt this was more of a marketing tool than a straight drive to reduce environmental impacts. The activities undertaken to get towards the accreditation were not usually prioritised until a few days prior to the auditor arriving.

Used Approaches

Eco for Marketing

Talking about **0801**, **0804** (the company director) explained his point of view: *"She [0801] used to say, she struggled a little bit because she'd get lots of negative comments, people would take it as a little bit of a joke, where it was clearly and very strongly set out from the start that we only entered the ISO 14001 because we wanted to deliver something serious and it was not just a nice thing to do, it was also the a) the right thing to do but b) it was a commercial as well. I mean, it was not only a genuine agenda in terms of what we want to achieve for the whole ISO and sustainability thing but also a commercial direction for the business."* It was difficult to be sure who was talking in the interview; whether it was the figure of the company, the director or whether it was a truthful, relaxed worker expressing his views anonymously. This was witnessed across most cases when interviewing directors and managers. It often felt as if they were justifying themselves rather than plainly

Views

telling their stories; and it proved to add difficulty when trying to create a complete story of the cases.

There was one story regarding the implementation of Eco Design approaches in the design process that stood out as a typical example of the practices of the company. **0801** had researched a more environmentally friendly material for one of the products the company made. The current material was vinyl and she proposed to use bamboo which she had found was much better overall and was also an economically viable option. The initial push to use a different material was actually coming from the client, but it seemed the alternative was in every aspect a better choice that could promote the company's environmental credentials. However, talking about her experience after implementing this option for this one client; she explained: *"I know that hasn't made an impact on the design. [...] Next time they do a design for someone else, they will revert straight back to vinyl. It's the way they've always done it. So no, I've not implemented this, it's not embedded because it won't happen again"*.

Used Approaches

0802 was a product design intern for the company. He works on similar projects as **0801**. At the time of the following interview excerpt, **0801** had left the company a couple months ago. **0802** was still a product design intern at the company and **0801** had not been replaced.

Interviewer: *And so, have there been any changes to the product since this research on new materials? Environmental changes?*

0802: *I'm not a hundred per cent sure; could be.*

Interviewer: *I heard of a project where the design team used bamboo?*

0802: *Yeah, I think. But I don't get involved in that.*

*Feeling of
Responsibility*

0801 felt frustrated that the other members of her team, as well as the directors, were not as engaged as she was. **0802** was clearly unaware of the research she had done, of the materials she had found, and was in no way able to build upon her work.

*Sustaining the
Implementation*

0801's point of view was that if an environmental alternative fulfils its purpose and is working, it should be implemented and used. But she felt that **0802**'s point of view was different:

***0801:** From his perspective, it's probably: 'yeah but it's the same, so why bother?'*

In terms of communication, it was very clear from interviewing the different participants that there was a divide between the directors and the design team. **0801**, **0802** and **0803** all expressed the difficulties they had communicating within the design process. **0804**

*Problems of
Communication*

seemed quite condescending about the issue. After the different interviews, the interviewer could feel this divide and also felt like taking sides with the design team. This was also one of the difficulties undertaking this research. Being impartial and non-biased can be made possible by expressing everyone's views and making sure not to intentionally omit, for example, the occurrences of positivity from an interviewee that mostly provides negativity. But inevitably, across the process, the researcher felt for the design team and especially **0801**. The director **0804** knew of her struggle but was not particularly concerned and felt it was 'normal'. Having researched LEDs for the last five years, **0804** explains that "*it's better they don't know*"; knowledge transfer is too complicated and the knowledge is too broad and difficult to understand and that "*this is inevitable*". From the design team point of view however:

*Knowledge
Transfer*

***0802:** Communication is not good, it is a struggle because the directors keep things to themselves. It is not easy to work in.*

Collaboration

0803, the design manager explains: "*I think things could be improved by letting people have greater individual responsibilities. But I feel we're more in little boxes, apart. **0804** reports to all, all report to **0804**. He tells everybody what to do.*"

***0801:** One controls everything. [...] We've become the CAD people, the art workers rather than the strategists and the designers. I think we have such a great product and we have a great team. We've got all the elements that would work really well. Oh it's so depressing ha-ha! I think, we might take it rather personally as well because we are creative people.*

These problems extend further to simply ‘communication’. It influences the whole design process, to a point where the design process itself ceases to exist due to a lack of team involvement. **0802** explains that from his point of view the design process is basically starting with **0804** telling him what to do and follows with an iterative process, going back and forth to the director **0804** for his thought until **0804** is happy with the work done. The design brief remains in the hand of the director **0804** and neither **0802** or **0801** are in contact with any clients. **0803**, the design manager is not able to manage the designers (**0801** and **0802**) since the director does not provide a brief to her, and communication between the two is almost inexistent. **0803** simply works on projects by herself, for clients she has contacts with, using help from **0801** when needed. There are virtually no meetings of more than two people and most of those are made up of the director **0804** and one designer.

*Design Process
Involvement*

Interviewer: *Do you know about a certain materials library?*

0802: *I know it has not been added to since **0801** left, she was working on it.*

Interviewer: *Do you know what it contains? What it was/is about?*

0802: *It was about looking at different materials, to make our materials more sustainable; she used to get lots of samples.*

Interviewer: *Where are those now?*

0802: *In the back cupboard?*

*Sustaining the
Implementation*

About knowledge:

0802: *If you are speaking to someone else [than **0803**], you can never tell them something they don't already know. That's the frustration. Because how can you implement a new strategy if they don't want to know, because they don't need to know? They don't feel that I could tell them anything new. Even when I do tell them something new, they already have thought about that.*

*Knowledge and
Trust - Belief*

In all, it seems this problem of communication and knowledge transfer is leading to a lot of frustration. **0803** appears to see this frustration as a standard part of her work: “*I think frustration can only go so far. Delegation is the main problem. The designers are*

*Communication,
Collaboration*

not used to their full potential. They're only told what tasks to do. They're shut down. Frustration is part of the company structure. But it'll never change."

0801, talking during a second interview after she left company: *When we spoke about it during the first interview, I think it was where I realised they had no process and implementation was the reason I was frustrated, because nothing was being implemented. Until we discussed that, I hadn't put my finger on why I felt as if I was doing nothing and that was why. I stopped beating myself up about it. [...] It's like therapy, because when you go home and say to a relative that work is so annoying; you're not analysing what it is that makes you feel that way. But in an interview, you really sit down and self-analyse... Yeah, it was good actually, thank you! Ha-ha...*

0801, the graduate product designer was clearly the 'green champion' of the company. She was the most frustrated by the lack of processes, and of sustained environmental efforts. **0802**, the intern was less involved in the area of Eco Design. He did not feel it was his responsibility. But **0802** also felt frustration in the lack of communication and the lack of a structured design process. **0803**, the design manager had been in her role for years. She was used to this lack of design process. She was instead working on her own projects, trying to have as little involvement with the directors as possible. She felt better processes could be put in place and that delegating to the design team was imperative to improve their issues. **0804**, the director, also recognised that there were problems of communication; but thought those were inevitable and due to the nature of the hierarchy of the company. **0804** thought it was difficult to pass down knowledge. He felt that first, there was not enough time to transfer knowledge but also that it was often better if they did not know.

*Green Champion,
Frustration*

*Knowledge,
Collaboration*



This case (as well as the following two cases **10-Teal** and **11-Lime**) was taking part in a funded project aimed to help British companies implement Eco Design. This was achieved by giving support from an external team of Eco Design and Product Design research consultants to a company for the duration of an Eco Design centred project, in this case the main actor in **09-Red**. In **09-Red**, the main actor is an SME employing 80 staff. With an annual turnover of over £6 million, it specialises in designing and manufacturing merchandise display units for leading, branded high street chains in the UK. **0901** was its company director, **0902** was the account manager responsible for managing the client's account the project was for and **0903** was the production manager in charge of in-house manufacturing (fulfilling the largest part of the manufacturing needs). Aside this main actor, there was another four participants from three different organisations. A freelance product designer (**0904**), an environmental consultant (**0906**) from a small Eco Design consultancy; as well as a research designer (**0905**) and a lead product designer (**0907**) managing the project, both from a university research group.

The case consisted of 7 Participants and 10 Interviews.



Company Director
'Green Champion', Later on enrolled on an Eco Design PhD program



Account Manager
Liaise between her customers, the in-house design team and Production Manager

	<p>Production Manager</p> <p>Responsible for the shop floor (in-house) where the designed units are built</p>
	<p>External Product Designer</p> <p>Provided product design advice and worked with the Environmental Consultant (0906)</p>
	<p>External Research Designer (University Research Group)</p> <p>Also worked with the Environmental Consultant (0906)</p>
	<p>External Environmental Consultant</p> <p>Provided Eco Design knowledge</p>
	<p>External Project Manager and Product Designer</p> <p>Project coordination and supervision</p>

0901, the company director is the ‘green champion’ of the company. As **0902** puts it: *“0901 is doing lots of work and research in sustainability. He’s very keen in passing knowledge down, get on board and pass the message on”*. He summarises the rationale behind the project: *“Our projects move so fast in our industry that when we start to look at reengineering a product, we’ve already had to design a new one. So we want to have a fundamental look at how things are made. A big issue is that the afterlife is never considered. Our clients are only focused on new models; never on what happens to the old stuff”*. So the project was set, bringing external help to the company, to develop an innovative and more environmentally friendly solution to the way they design all their products, using one of their client’s products as a starting point. Note the focus was set on the design of the products, independently and regardless of their manufacturing skills or capabilities.

Green Champion

Lack of Time for Innovation

During the interviews, the discussions regarded the project itself and its design process, the way it happened and the views the different participants had; but also centred on the past experiences of each of the participants.

From the interviewer's perspective and from the start, it seemed difficult to understand the role of the different participants, their relationships or the overall organisation of the project.

*Organisation
Collaboration*

The structure of the main actor's company was somehow clear since they operated outside of this project with similar function. **0901** was the director of the company and the lead of the project's participants in the company; while **0902** managed the client's account and brought input to the project from her experience working in the industry and with the client. **0903** was the production manager of the company and bridged the work between the in-house design team and the production floor. Within the project, he was

Design Process

consulted for his experience in the industry and manufacturing experience of the production floor capabilities. It is interesting to note that none of the members of the design team from the main company were actually involved or consulted. It seemed throughout the interviews with **0901**, **0902** and **0903**, that the design team had no time to dedicate to

*Lack of Time for
Innovation*

side-projects, no time for innovation and no time to focus on a project which was not directly bringing profit to the company. **0901** explained this was also a reason why his company needed help and why they had not been able to implement Eco Design approaches or any innovative thinking so far. However, throughout the course of the project, none of the designers were involved or helped.

Then, there was the set of consultants commissioned to help the company. There, the relationships were a little trickier. There were three designers with two from the same design group and responsible for the project (**0905** and **0907**), and one from a design consultancy (**0904**). **0907** was the lead of this design sub-team, the direct manager of **0905**, and the project manager of **0904**. **0906**, the environmental consultant was somehow aside from this design team but remained managed by **0907**. Altogether, this project team was made up of three organisations, one project manager and three consultants.

It was the relationship between the main actor and the other participants which the different participants found difficult to grasp and to work with. **0904** was not sure who the client was; whether it was **0907** the project manager or **0901** the company director. **0904** felt **0901** was his client but yet, that he was not able to communicate and work directly with him, and that this was hindering his progress. Alike in the previous case (**08-Gold**), **0904** never had access to the brief of the project.

*Design Process
Collaboration*

*Problems of
Communication*

In the main company, although the rankings were more established, the roles and motivations were not. **0903**, the production manager had a completely different view from **0901** on design and generally the role of the company. **0903** role is to feed the production floor with work; work within the manufacturing capabilities of its tools and its team. He was therefore not as positive and engaged in regards to design innovation as the company director and the external design team may have been. **0903**, explained: *"The shop floor is ultimately what you're feeding, they need work"*. Talking about the project, he added: *"we need work, that's not giving us work"*.

*Conflicting
Objectives*

0902 was much more sensitive to the environmental issues surrounding the work of her company. She felt bad about the amount of waste generated in the industry and the lack of consideration for end-of-life. When discussing the overwhelming longevity of their products, she explained she was not interested in planned obsolescence, although that yes, they did build products that could unnecessarily withstand wear and tear: *"Sometimes, I feel very guilty here, of building units that will survive a bomb."* Torn apart between guilt for using too much resources and wanting to offer a product that lasts, were sentiments also felt by the company director, and relate to the guilt and frustration **0801** felt in **08-Gold**. It is interesting that this case, **09-Red**, had these two top employees feel for the environment in such a way; almost against the stereotypical sales-like reaction of wanting to sell more, cheaper, faster, without other considerations. Both actually felt genuinely bothered by their company's actions on the environment.

*Feeling of
Responsibility*

Frustration

Within the external project sub-team, the story is sparser. The participants there felt disconnection between all actors. They felt as if they each were contributing but were not heard by the others. They also each had significantly different opinions on the aims of the project. **0905** was adamant this was about better design, and clearly voiced he was not interested in the environment. **0906** felt there was tremendous room for improvement and that such help to the industry was needed. Yet, his expertise seemed to lack the industry touch. **0905** explained how **0906** had found an apparently good environmental alternative material; but that the replacement was only manufactured in the USA, on small scales and that it was therefore a choice disconnected from the reality of their industry. However, it is interesting to point out once more that he never received a design brief as such.

Problems of Communication

Lack of formal Design Process

In this case, the motivations and interests of the participants proved to be very different. Not fitting the public stereotype, the company director was the one that expressed the most interest in greening its product and company activities. And although it remained that cost could never interfere with this goal, he expressed he was inclined to the idea of restructuring his whole business to do so if needed. Down below the hierarchy, the production manager also felt for the environment but did not see the company's activities in the same eye. For him, giving work to his employees on the production floor was the sustainable thing to do. The environmental aspects of sustainability came second. The sales person, account manager (**0902**), also did not fit the stereotype of a sales-driven individual. She truly sympathised and expressed concerns regarding the waste her company and industry generated (directly and indirectly), and regarding the wasteful use of materials in their designs. These dynamics were very interesting to witness. Amongst the external consultants, less unanticipated dynamics took place. The product designers had little understanding of the environmental side of the brief, they felt cost and innovation played centre stage and felt frustrated by the team communication and design process. The environmental consultant was seen as 'out of touch' and not knowledgeable of the industry realities of supply and production; while he felt he may not have been engaged as much as needed. Interestingly, these conflicts of relationships seem to resonate from the previous case, **08-Gold**.



This case also followed a specific design project, with different companies involved in the same configuration as **09-Red**. The main actor in **10-Teal** is an SME designing, engineering and manufacturing train seats with 40 employees and an annual turnover of about £3 million. The business and design process of this company adheres to very different constraints, timelines and objectives in comparison to the two previous cases. This is reflected below in the narrative and the coding of the data. The project intended to cut the weight of a typical pair of train seats from 35kg to around 25kg while maintaining flame retardancy, seat strength and security, passenger comfort and so on. Aside from this main company, there was another three participants: a design engineer (**1005**), an environmental consultant (**1006**) and a lead product designer (**1007**) managing the project.

The case consisted of 7 Participants and 8 Interviews.







Managing Director
Overseeing the project, Providing industry knowledge



Engineering Design Manager
Knowledge of the company's designs, Liaising with all



Computer Aided Design Engineer
Helped the build of design concepts

	<p>Product Designer Developed design concepts</p>
	<p>External Design Engineer Consultant Provided engineering alternatives</p>
	<p>External Environmental Consultant Researched alternative materials and processes</p>
	<p>External Project Manager and Product Designer Liaised with all parties and managed the design process</p>

The company used the expertise from the different subsidiary actors to find new ways to innovate and reduce the weight of their seat design. With train seats and other products, parts of moving vehicles, lightweight design is at the same time an environmental and an economical objective. Any design steps enabling to lower the weight of a seat will enable to save on the use phase of the product's fuel consumption; therefore becoming

both environmentally and economically preferable. Reducing seat dimensions is also a key objective for both the environment and for the bottom line. The smaller the depth of the seat, the more rows of seats can fit per carriages and therefore the more people can be seated on per train. This in turns enable to reduce the number of carriages and trains needed on the rail network, saving fuel, fuel emissions and money.

*Approaches,
Objectives*

In such a case where economic and environmental advantage runs along such a blurred line, it is difficult to figure out the motivation of the participants. The discourse tend to lean towards fuel saving but it remains unclear as how this is might be driven by environmental aspirations. Other constraints coming from legislation and from train

Legislation

manufacturers, ask for recyclable and fireproof materials, such as wool. While also contributing to the environmental bottom line; it is here again difficult to understand at first sight, how much environmental objectives weight in the selection.

Another constraint, similar to **09-Red**, regards the manufacturing capabilities of the company. At first, the company maintained a manufacturing facility predominantly using steel tube-bending for primary manufacturing process. This constrained their designs in some ways. Choosing to design a seat through a manufacturing capability they did not own in house would force them to outsource the manufacturing, increasing their costs. This could also make their manufacturing unit lose money and ultimately become obsolete. Therefore, steel tube-bending played an important part in the brief at the beginning of the project. However, half-way through the project and due to a lack of work in the industry (emerging from the global economic crisis); they faced the hard decision to let go of their manufacturing unit and its staff which they could not sustain anymore. In some ways, this also enabled them to open their design options and see their design process in a different light; with less materials and processes constraints, but with more stringency on manufacturing costs due to heavier reliance on suppliers' prices.



Economic Crisis



Innovation

The main company was undergoing lots of changes in the background from the start; which were later on brought to light as part of a business reorganisation. This might have been the reason why **1001** and **1002** (the Managing Director and Engineering Design Manager) were difficult to contact and most likely a reason to understand their reticence to express themselves on the project within this research. However, towards the end of the project and the interviewing process, both **1001** and **1002** felt much more open and genuinely interested to talk about the developments of the project. In parallel and with little knowledge of what was going on, **0903** and **0904** (designer and engineer at the main company) were from the beginning happy to discuss their practices and the project. They experienced similar problems as the previous cases, namely, a lack of knowledge regarding the design brief and a lack of understanding of both the external team's role and the environmental objectives of the project.



*Design Process
Involvement*

They also showed a clear lack of environmental knowledge and little interest towards the subject. Again, an argument can be made that although they did not go about practicing Eco Design as such, their main design objectives and activities (e.g.: lightweighting) were in line with reducing environmental impacts and use of resources.

It was clear during the interviews that there was a lack of communication amongst the project's participants. The design brief was largely kept by **1001** and **1007**. The other involved designers knew little apart from the overall need to reduce weight; while the environmental consultant (**1006**) was little involved altogether. Even by the end of the project, the external participants (the design and environmental consultants) were unaware of the big changes the company had undergone. For example, the chosen design opted for an innovative aluminium extrusion process. The consultants thought this process may actually be unrealistic since the main company's manufacturing facilities did not possess the equipment or expertise in this process. The consultants were actually unaware the main company had ceased its in-house manufacturing activities altogether due to economic hardship. The environmental consultant provided 'packages of information' without actual involvement in the design process. He first provided a selection of alternative materials. But **1001** dismissed them as they did not fit regulations (a consequence on the lack of knowledge of the brief). He then provided Eco-Audits of the baseline and alternative designs. This exercise was not used by the company and did not influence the design process in any way. It is interesting or even surprising the environmental consultant did not have more involvement in the design process and that his knowledge rather than participation was sought after.

*Lack of
Communication*

Economic Climate

*Knowledge,
Collaboration*

The main design input came from **1005**, the external design consultant. A lack of understanding of the company was controversially a blessing in disguise for the future of the project. Little aware of the manufacturing capabilities (which, alike in **09-Red**, hindered the company in-house design team); he engaged on developing a seat frame using extruded aluminium. His main given objective was to lower weight. He had no

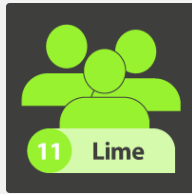
*Lack of
Communication*

awareness of the environmental reasons behind this objective, and he did not consider his work to have anything to do with Eco Design.

This case and project had a confusing chain of events and unclear workflows. Eco Design was present, but this was not due to a commitment towards lowering environmental impacts for environmental concerns. Lowering weight for greater fuel economy was the factor. The project did not have any 'environmental champion' as such except, by default, the environmental consultant. At the very end of the case interviewing process, something quite surprising emerged. The main actor company also had access to a graduate intern sponsored by the government, which had worked all along on the same seat, focusing on its attachment to the train itself and working towards the same objectives as the external design team. It came as highly unexpected that neither the interviewer nor the participants had knowledge (yet relationships) with this person. This detail reflects the way the whole project operated; with a lack of transparency of information, and a lack of communication at every level.



*Efficiency
vs Eco Design*



This case followed the same funding structure than **09-Red** and **10-Teal** aimed to help British companies implement Eco Design; where Eco Design expertise was provided to the main company in **11-Lime** for the duration of an Eco Design centred project. In **11-Lime**, the main company is a large retailer of building goods. It employs more than 5000 people and has an annual turnover of more than £1.3 billion. They supply construction materials to the building trade through nationwide stores, and although they do not directly manufacture; they greatly influence their suppliers to follow their needs and objectives. At the time of this research the company's goal was to make packaging for screws and nails more volume-efficient, in line with legislation, policed by the UK's trading standards body, relating to the excessive use of packaging. **1101**, a Quality Assurance Manager from the main company explains the project: *"We sell in stores, to the public, nails and screws in packs of small quantities. Because the packs are too big compare to what is inside, the training standards have asked us to redesign the packaging so to use less materials and space. But this gives us a challenge in regards to putting all the information needed on the pack and also to coordinate potential changes with our suppliers, and manage their current capabilities"*. **1102** and **1103** were respectively the external product designer and project manager. **1104** was the external environmental consultant.

The case consisted of 4 Participants and 5 Interviews.

	Quality Assurance Manager Project Manager from the main company
	External Product Design Consultant Provided concepts
	External Project Manager and Product Design Consultant Liaised with the different parties
	External Environmental Consultant Provided research on new materials and processes and streamlined LCA of the existing and proposed designs

The first person interviewed in this case was **1101**, the Quality Assurance Manager. He explained the project came along when on one side the training standard had asked his company to reconsider the resource use of their packaging and on the other side; he had been in touch with an Environmental Consultant (**1104**) which informed him of a governmental funded program he could benefit from. The company was already, prior to the event with the training standards, working on a better packaging for their nails and screws. Their main interest in developing a better packaging was for it to help sell more and to be more efficient if possible. As **1101** explained, the training standards' 'stick' of a fine for not reducing the materials and size of the current packaging was a minor, if not insignificant driver to change the packaging. However, he continued explaining that the consequent potential damages in terms of customer relationship, branding and marketing was a much more

Eco for Marketing

important threat and therefore 'stick' or driver for change. **1101** himself felt a little confused as to the primary objective of the project. The environmental aspect did not influence his decisions, and

Unclear Objectives

he was simply concerned in making the packaging more efficient. The project

however set to lower carbon emissions and embodied energy of the product; principally at the materials, transport and end-of-life stages. Alike in the previous case (**10-Teal**); it is interesting to note that to a large degree, these differences in views are due to language. Indeed, in either way of looking at the project, efficiency or lowering environmental impacts, the design outcomes would satisfy both parties. This is again due, alike in **10-Teal**, to where the environmental impacts are the largest: the transport stage. Saving packaging material and size, ultimately save energy use during transport; contributing to both environmental and economic bottom line.

*Efficiency?
Eco Design?*

However, and this is where the views diverged, using packaging to sell more (the primary objective of the company) can conflict with the reduction of environmental impacts. Indeed, **1101**'s managers were mainly interested in a packaging that could show the product in its best light while containing the necessary label information. Cost was also important. These objectives were confronting each other. Trade-offs would need to be made. This relates to **09-Red**, in that **0901**, the company director, also wanted the most environmentally friendly, the cheapest and the most innovative solution at the same time.

*Conflicting
Objectives*

The external design team first came into the project through **1102**, the main designer for the project. He was aware of the brief and its ambiguities; but he quickly sided towards the innovative objective. The design used two types of materials (card with a transparent window made of polyester). Although **1102** never heard it from **1101**; **1101** explained in the interview how he had always been against a design with a window because it would make the packaging too expensive. However, in the meeting where **1102** presented the design to the project team and the company managers; everyone seemed very happy with the concept. It lowered environmental impact by reducing weight and size and clearly increased the product presence and appearance on shelves.

*Lack of
Communication*

However, later on, in a last interview, **1101** explained his managers had decided to scrap their market research, scrap the work of the design team and to go for the lowest price option, with a polyethylene bag and a sticker for the label

information. **1102** was unhappy about the decision. He actually felt from the beginning this was the best solution if their main concern was price; but he believed the main objective was to innovate to increase the sales of the products.

Interviewer: *Do you think the PE bag design is the good solution?*

1102: *It's the cheap one. The cheapest.*

Interviewer: *Does it have other advantages?*

1102: *It's easy to pack and easy to fill, with nearly a 100% bag filling.*

Interviewer: *So, does it make it a sustainable solution?*

1102: *No. It's made out of non-recyclable plastic.*

*Lack of Knowledge
(PE is recyclable)*

Interviewer: *Why is it not recyclable?*

1102: *I don't know. It's a good solution but it was not what the brief said. The whole exercise was waste of time.*

Interviewer: *Do you think this decision was cost-driven?*

1102: *Yes, sustainability is not much there anymore.*

Interviewer: *According to the brief, which design is the best?*

1102: *Mine.*

Interviewer: *And in regards to the environment, which one?*

1102: *If the bag recyclability is addressed, then the bag. If not, still the bag because it is a much lighter process. The bag was always better. No matter what we did, the bag was better, it's irritating.*

Frustration

In regards to the Eco Design aspects, this simple bag was also the best option. It used very little resources and it reduced size to a minimum. Therefore, in regards to this objective, the project was also successful. However, both parties (the external team and the company's **1101**) felt the project had not been a success. A lack of consensus on design objectives and collaboration throughout the project led to a very inefficient design process, but (and likely by luck) to the adoption of the greenest, cheapest option. In the end though, **1101** and the design team had concerns. They all felt this may have been the best option for price (and consequently environmental impact); but it may have been a short sighted decision. They feared the use of a less appealing and less substantial packaging may lower the sales of the products and therefore ask for reconsidering the packaging once again.

5.3 The Themes (Initial Version)

In the previous chapter, during the initial pilot study, initial insights for themes were identified and discussed in reference to the literature. In section 5.2 of this chapter, these themes were explored further following the structure defined in section 5.1. In this section, each of these pre-set theme that has been extracted from any, some or all of the four cases during the analysis is defined. Themes that have only emerged from the analysis are also defined (and labelled as such). The next section (5.4) then presents the data behind the thematic and comparative analysis undertaken across the cases.

The following presents the themes and their definitions as they emerged from the thematic analysis (5.2) (phase 3 to 5 of the thematic analysis process described by Braun and Clarke (2006) and presented earlier in Section 5.1) and from the following comparative analysis (5.4). Those themes are presented now to enable the presentation in the next section of the gathered data that represent each of them.

A. Views

Whether Eco Design is seen positively or negatively. This theme covers the interviewees' personal opinion on the discipline in the context of their industry.

A¹. Ethics (emerging sub-theme to A. Views)

This theme considers the personal engagement of interviewees in environment issues. It describes the environmental investment of some of the participants, how some felt that they were the 'Green champions' of their teams/company and that dealing with environmental issues was about doing 'the right thing'. The theme also encompasses note-worthy, opposite views.

A². Responsibility (emerging sub-theme to A. Views)

This theme groups the views of the participants on their sense of responsibility vis-à-vis of Eco Design implementation. It considers their feeling of Eco Design implementation being: out of their personal/company control, not part of their own responsibility, not asked for, uncared for because of the way markets are organised, etc.

A³. Time and Trust (emerging sub-theme to A. Views)

Lack of trust in the available environmental information and environmentally friendlier available materials/designs, and lack of time to investigate, undertake research. Fear to do the wrong thing, fear it could backfire.

B. Objectives

Whether and how environmental objectives (Eco Design objectives) are part of the design brief. Also regards environmental objectives that are conflicting with other design objectives.

C. Adoption

This descriptive theme considers which (if any) Eco Design principles or approaches are either considered, or driving projects and the design process.

D. Approaches

Collects the information on Eco Design approaches (including Eco-Tools) that had been given thought to. Also includes participants' views and opinions on the usefulness of those approaches.

E. Knowledge

Designers and teams' knowledge of Eco Design. How the knowledge is developed (e.g.: individually).

F. Sustaining Implementation

How implementation is sustained, whether there are processes in place to drive further steps in Eco Design implementation.

G. Communication and Collaboration (emerging theme)

The (hindering or enabling) effects of Communication and Collaboration in the implementation of Eco Design. How Eco Design related information is communicated. How information is driven across teams and clients. How information is used in a collaborative way to improve the design process. How participants feel about communication and collaboration as being a potential issue to Eco design implementation.

H. Economic Climate (emerging theme)

The effect of the current and past economic climate on the adoption and implementation of Eco Design.

5.4 Comparative Analysis

Section 5.1 and 5.2 described the method used to extract the themes from the data and in the previous section, an initial version of the themes was defined. This section presents a comparative analysis of the occurrence of the themes across the cases, presenting by themes, direct quotes and short, illustrative narratives.

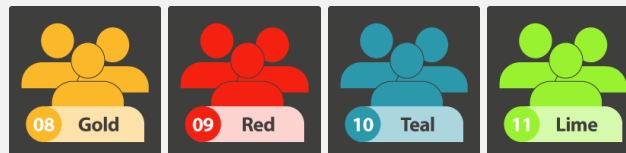
For each case, the context of the presence (or absence) of the themes is different. For example, certain cases may include no appearance of Eco Design adoption, yet have a lot to say about the barriers to Eco Design implementation; while other cases may provide strikingly different ways to Eco Design adoption. It is the experiences lived by the participants and the challenges faced when implementing Eco Design approaches that shape these themes within each case. This comparative analysis explores below these different ways in which each of the themes occurred in the different cases and provide an initial understanding of the potential drivers or barriers to Eco Design implementation.

The themes are presented below in the following format:

- The theme heading and definition;
- An introduction to the theme with reference to the literature in that area;
- A discussion of the findings relating to the theme; including short narratives, quotes and descriptions;
- A discussion on the frequency and importance of the theme;
- A conclusion on the key findings and the implications of the theme for the implementation of Eco Design.

A. Views

Whether Eco Design is seen positively or negatively. This theme covers the interviewees' personal opinion on the discipline in the context of their industry.



Present across all cases.

This theme corresponds to the first of six interview topics presented in section 5.1. All interviewees were asked about their views on Eco Design, both personally and from their company perspective. Therefore, this and all six topic/themes are present across all four cases. Several common general opinions were expressed and are developed below; while three different perspectives that occurred repeatedly are classed as sub-themes. These, named 'A1. Ethics', 'A2. Responsibility' and 'A3. Time and Trust' are developed afterwards within their own sections.

Most participants felt Eco Design was an important topic and aspect of Product Design. They wish they could do more but usually found it impossible; feeling frustration, confusion and a certain degree of cynicism. There was frustration about the lack of progress in the greening of products; confusion regarding the routes to take and choices to make to achieve Eco Design and cynicism towards the industry realities of Eco Design.

0901, the managing director of **09-Red** explains: “[What we do,] it’s so heavy; it’s so wrong, so wrong [...]. We have the green wash with our environmental bit on our website, but it is rubbish, it’s a blur. It’s like: ‘What about the sustainability? Oh yeah I know, we must write something about it somewhere’. I mean, we send skips to landfill two to three times a week! It’s obscene.” **0901** expressed both his personal interest in Eco Design and his strong desire to ‘green’

his company. However, he also expressed his feelings of hopelessness, sometimes cynically, about the possibility of implementing Eco Design in his company. This drive from a top management position was not seen across the other cases, but is aligned with the findings from Boks (2006) and Short et al. (2012). The other cases all had a company statement on the environment, but **0901** was the only head that actually communicated his willingness but despair regarding the implementation of Eco Design. This hopelessness and despair had to with collaboration and relationships with staff. He wanted to accommodate the views, feelings and desires of all, but faced strong opinions presenting barriers (such as **0903**, the production manager).

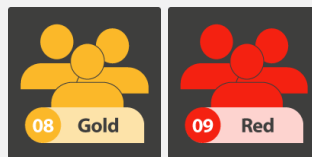
Amongst lower level staff, **0801**, the graduate product designer from **08-Gold** is a good example of how designers can be invested in Eco Design. **0801** encountered a difference of view in her company when she felt (or realised) that **0804** (the managing director) was mostly interested in the publicity that the environment topic could bring. Across the other cases, most participants saw Eco Design as a good thing and wished they could do more; but they also felt as if it was out of reach or possibly unfeasible. However, certain participants, such as **0802** and **0905** were actually not so interested in Eco Design. Both graduate designers, it was interesting to see such a low level of awareness or interest in the topic amongst a younger generation. **0802** simply stated: *"I don't get involved in that"* while **0905** explained more plainly: *"I don't pay any interest in that"*. Surprisingly, there does not seem to be a correlation between the age or role of the participants and their views on Eco Design, although the number of interviewees and amount of roles in this research does provide enough validity to fully assess this possibility. Amongst the cases, some of the younger designers did not care so much for Eco Design; while certain participants in senior roles advocated for it. It is interesting to note (so far) a discrepancy between these findings and a certain stereotype that sees younger roles and generations as more environmentally inclined.

There also was a sentiment that Eco Design is not economically feasible, supported in the literature by Lindahl (2005). This is explored in the last theme, 'H. Economic Climate'.

Finding: There is a general feeling that Eco Design is an important part of the product design process, but that it is in practice difficult to incorporate. There are feelings of frustration and cynicism towards the (lack of) implementation of Eco design, but also some indifference by some participants.

A¹. Ethics

This theme considers the personal engagement of interviewees in environment issues. It describes the environmental investment of some of the participants, how some felt that they were the ‘Green champions’ of their teams/company and that dealing with environmental issues was about doing ‘the right thing’. The theme also encompasses note-worthy, opposite views.



*Present across cases **08-Gold** and **09-Red**.*

This theme is the first of three sub-themes to the general theme ‘A. Views’ presented above. This is also the first theme explored here that was not teased out during interviews but appeared through the coding of the data (the methodology of which is explored in section 5.1). ‘A1. Ethics’ relates to the cases **08-Gold** and **09-Red** where participants show great empathy towards environmental problems in relation to their company’s production. It is also interesting to point out that out of all four cases, **08-Gold** and **09-Red** are the most environmentally engaged companies (as seen in section 5.2), and that there may be a link between the employees’ empathy and a company’s environmental stance.

When asked about their designs, **0902** admits: “*Sometimes, I feel very guilty here, of building units that will survive a bomb.*” But later on in the conversation,

when asked about why they design products that last twice as long as their briefs specify:

Interviewer: *Why do you design products that last ten years?*

0902: *We don't do it that way, but we've seen it does.*

The company ends up throwing away perfectly good units because they fall out of fashion, rather than for wearing out.

Interviewer: *Are you not losing jobs by making units last so long?*

0902: *You are but... I don't know. I think it is better for sustainability as well. If you are going to make something, you better do it good and right from the first time.*

Interviewer: *So what do you think about planned obsolescence?*

0902: *I disagree with that. But I think we're maybe a bit guilty of making things last...*

There seems to be a certain struggle for **0902** in the way their products are made. On one side she feels they are too heavily built (adding potentially unnecessary materials, weight, transport, etc...); which can be perceived as unsustainable. On the other side, she feels it is good practice to create products that last, that it is more sustainable to do so; even at the loss of jobs. This actually seems to defy the economic arguments encountered so far. But another interesting point to add is that **09-Red** does not necessarily intentionally design products to last so long; it just happens (*"We don't do it that way, but we've seen it does"*). Maybe the durability constraints make these products inherently last so long; but one is left to wonder whether there is not just a lack of design knowledge from the design team in being able to develop products that only last the required time asked by the brief. However, there is no clear cut answer as to whether their current design model or a less robust one would be more beneficial to the environment.

0901, the company director in the same case also feels heavily concerned for the environment; showing a real investment in the matter, later enrolling to do a part-time PhD on the subject. **0901** expressed what he felt to be a need from his industry to be more involved environmentally. This relates to his feeling of

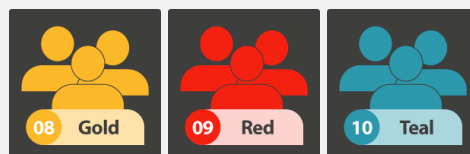
responsibility towards environmental improvements; a theme discussed below in 'A2. Responsibility'.

In **08-Gold**, **0801** (a product designer) was the most involved in terms of environmental issues and Eco Design. **0801** believed taking care of the environment was more than part of her job but also part of her day-to-day life. These ethical views were further explored in the thematic analysis surrounding **08-Gold** (Section 5.2).

Finding: Some participants take Eco Design and environmental issues particularly to heart. They truly feel for the environment, and strongly believe in the need to do more as a society. These participants also show personal involvement, way beyond the requirements of their roles.

A². Responsibility

This theme groups the views of the participants on their sense of responsibility vis-à-vis of Eco Design implementation. It considers their feeling of Eco Design implementation being: out of their personal/company control, not part of their own responsibility, not asked for, uncared for because of the way markets are organised, etc.



*Present across cases **08-Gold**, **09-Red** and **10-Teal**.*

In the context of the themes of this research, 'A2. Responsibility' represents the views of participants that felt that Eco Design was more than the right thing to do, and felt in fact a sense of responsibility to engage in the area. This

theme however relates as much to how certain participants felt responsible as to how others did not.

0901 felt responsible for his company's products; the amount of wasted materials, units sent to be disposed of before their end of life, and the lack of recycling. But **0901** also felt powerless towards addressing these issues, as his clients did not feel the same sense responsibility.

0901: Nobody during that [product development] process has an incentive to make it good. [...] They [our clients] don't give a toss about sustainability.

0902 also felt the same way. But she felt it was her company's responsibility, as designers and manufacturers, to lead and provide their clients with innovative environmental knowledge and solutions. However, the production manager, **0903**, explained that the problem was that on the other end, their clients were not feeling any shared level of responsibility. When offering to work on Eco Design, a customer's usual response was: *"What's in it for me?"*. The face of customers in the industry is usually a buyer or otherwise financially inclined person, tasked to source a product with cost being the main criterion.

1001, as a director, sees the industry in this way: *"Life time costing is a concept that is more and more accepted but I still doubt its implementation because deciders [the customers] will not be here in ten years, therefore they still prefer to take the cheapest front-end option"*.

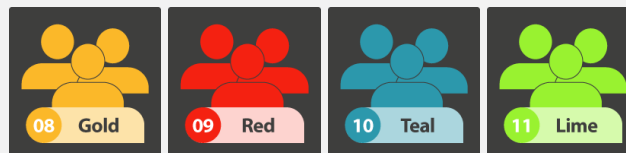
On the other side, certain participants openly expressed their lack of interest and feelings of responsibility towards lowering the environmental impact of products. For example, although an essential participant of the project in terms of design, **0905** (product designer) was quite strongly dismissive of the Eco Design aspects. Asked about the measurement of the environmental impacts of the new solution, he stated: *"I pay no interest in that"*. In **08-Gold**, **0802** (design intern) also expressed his lack of involvement expressing it was simply not part of his job to do that (Eco Design). Interestingly, this attitude is also seen in Van Hemel's survey (1998) of SMEs that found that the lack of responsibility from the participants was one of the strongest barriers to Eco design implementation.

The lack of responsibility can be seen to lead to a lack of requirements and demand from the customer in the design briefs. This is further explored in theme 'B. Objectives'

Finding: Certain participants feel responsible for the production (direct or indirect) of their designs. Similarly to theme 'A1. Ethics', these participants feel the need to push for the implementation Eco design. Other participants dismiss Eco Design and responsibility in contributing to environmental impacts. This attitude seems to be a barrier to Eco Design adoption.

A³. Time and Trust

Lack of trust in the available environmental information and environmentally friendlier available materials/designs, and lack of time to investigate, undertake research. Fear to do the wrong thing, fear it could backfire.



Present across all cases.

This theme is classed under 'A. Views' because although time and trust is a recognised factor of Eco Design implementation in the literature (see section 2.5). The findings correspond here to the *perceived* lack of time for, and trust in, Eco Design by the participants. Most participants mentioned having a lack of time to look at Eco Design and/or a lack of trust of Eco Design or environmental alternatives. These two aspects have been grouped in one theme because they were usually expressed at the same time and related to one another. Eco Design was expressed as an activity designers would like to carry, but could not due to time pressure on the design process; other design objectives were taking priority.

Outside of the project design activities, they also explained they had limited opportunities for personal or professional development or research. Day to day activities were always the priority and did not allow them time to verify Eco Design claims from suppliers or the competition. They lacked the confidence to adopt a new material, or design element, due to a lack of reliable data or testing of the alternatives.

As for the rest of this research so far, Eco Design and innovation seems clearly linked (as seen in the literature review, section 2.2 and 2.5). Eco Design is seen as a form of innovation, whether it is the implementation of new green innovative designs or materials or processes. In all four cases, there were consistent mentions towards a lack of time for innovation (e.g.: **0803**, **0901** and **1002**); which in turn seemed to hinder the research and implementation of environmental alternatives.

In his latest research, Deutz (2013) explains: *“Companies are typically drawing on a highly restricted actual design space, strongly favouring familiar solutions to problems. This greatly restricts the possibility of a solution that represents a significant break from current practice, which a truly sustainable solution is likely to be.”* Meanwhile, the lack of trust in Eco Design by practitioners has been widely shown in the literature for many years; by, for example, Araujo (2001), Lindahl (2005), Jänsch and Birkhofer (2007) or Design Council (2010). Both these issues of time and trust are discussed in the literature review (section 2.5).

For this theme, two short narratives are presented below. These present the emergence of the theme (lack of trust and time) across cases. The first narrative below presents the participants' views on their perceived lack of time for, and perceived value of, innovation.

Interviewer: *How do you enable innovation, research and development in house?*

0901: *Well, this is very difficult because we are in a fast moving, project-driven industry and just achieving that puts our work force under lots of pressure. There is no department or resource for R&D. Also, if we had a bit of time, we would be tidying up CAD files, possibly revisit project; we would not be looking at new technology or innovation. LED lighting came to us and we embraced it. So if someone came with an alternative for MDF, half price and half the weight; we'd*

look at it. But why fix something that's right in a way. I see no sustainability in our industry. We have no time to even get clients to buy into a new concept; by then, we're already onto the next project.

0901's view seems resigned and almost accepting of the status quo. But this view comes from the same person that directs the company and is driving the sustainability efforts and activities. And this example shows the struggle participants felt across the cases. On one side they blame a lack of influence or leverage on clients and the industry to devote time to innovation; yet, on the other side, they also believe that if they had time; it might be better spent on other activities than innovation (as shown in the quote above). **1005** also explained how crucial it was to get the design right quickly, that the design process was fast-paced and that they could not afford to fail on a design because of too daring, innovative ideas. As **0804** put it: *"Time is the main driver and we are lacking the time to develop and integrate sustainable solutions because we're already stretching ourselves too far"*. Le Pochat et al. (2007) and Handfield et al. (2001) also find lack of time in the design process is a great barriers to Eco Design implementation.

Linked to a lack of time to devote to Eco Design and innovation, there is a lack of trust towards the new potential environmental alternatives brought to design process.

0803: *We've been looking at recycled aluminium, we should investigate more.*

Interviewer: *What do you mean?*

0803: *We still use virgin aluminium.*

Interviewer: *Why is that?*

0803: *It needs more looking into, it needs time. Devoting time. We would need to do small run. They [the suppliers] told us it will not change the materials properties, but if it did, then we can't have that. We have no time in the current project's timeline. To do what we'd like to do properly, we'd need a period of time before a project to properly R&D it. It really isn't a case of I don't care. I do care. It's just a case that there are other things that need to happen so it's quite difficult to put it in.*

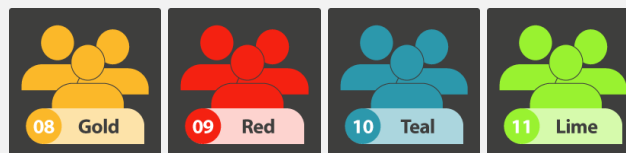
In all cases, new materials were brought to the attention of the design teams and there was reluctance to accept these alternative solutions. In **08-Gold**,

there was a fear that the recycled aluminium would not behave similarly to the virgin one and pose structural and/or aesthetics problems. In **09-Red**, a new design, integrating alternative materials was proposed to customers as a way to save money and greatly reduce environmental impacts. But the customers did not feel confident the solution was tangible and also did not see much need for it. In **10-Teal**, a new process of aluminium extrusion was proposed by Eco Design consultant and engineers, but the main company was wary of investing in a new process, albeit taking into account its advantages. Lastly, **11-Lime**, the use of new materials was only considered through marketing surveys and with little environmental consideration.

Finding: The fast-paced nature of the design process hinders Eco Design implementation, which requires time and resources that are not available. Designers have little to no time allocated to research on new materials and other innovations. This includes time to consider Eco Design alternative – let alone time to test or assess alternatives.

B. Objectives

Whether and how environmental objectives (Eco Design objectives) are part of the design brief. Also regards environmental objectives that are conflicting with other design objectives.



Present across all cases.

This theme corresponds to the second interview topic, as defined in section 5.1 (Methodology, Data Collection). This theme covers an initial requirement for Eco Design implementation: the presence of Eco Design objectives in the design brief. The theme is part of three connected themes with 'C. Adoption' and 'D. Approaches'; where Eco Design objectives are seen as a condition for subsequent adoption, itself coming first before the use of approaches.

As mentioned earlier in section 5.1, the projects followed in this stage of research were funded and focused on Eco Design. This was not the primary focus of the main actors in the standard practices. Therefore, the objectives of the projects studied did not reflect the objectives normally encountered in day-to-day projects by the main actors. In all cases, little evidence of Eco Design objectives was found outside the followed funded projects. However, the participants' experience and opinion towards these new set of design objectives proved to be very insightful on the difficulty of implementing Eco Design. It was also felt that the following research stage (presented in chapter 6) would be able to provide insight into how companies integrate Eco Design objectives into their day-to-day projects. An account of the difficulty to integrate Eco Design objectives in the design brief (prior to the design activities) is presented below.

08-Gold, 09-Red and 10-Teal had a production floor. In **08-Gold**, this was a simple, small workshop; both in physical size and in terms of employees. But in **09-Red** and **10-Teal**, the production floor occupied a large portion of the company. In these latter two cases, the companies were making significant savings by manufacturing in-house and were able to greatly control the development of their designs. Both companies felt it was a great strength to be able to learn from the production floor. It enabled them through design iterations, to learn from manufacturing mistakes and ingenuity. However, upon interviewing the participants from both these cases, it became obvious this strength was also holding them back. **0901**, the company director, recognised it was difficult to imagine designs that did not use their manufacturing capabilities. Indeed, one of their design objectives was to use in-house production methods. While they outsourced some of their parts, they could not afford to not use the production floor altogether, since it was a part of the business. **0903**, the production manager, was the most adamant about this: *"The shop floor is ultimately what you're feeding,*

they need work". Talking about the project, he added: "*we need work, that's not giving us work*". There was a conflict between the company's objectives to produce using their own manufacturing capabilities and the Eco Design objectives that provided solutions that used different methods. Also, discussing this issue with **0901**, the company director, there seemed to be some sort of a catch 22. He agreed the production floor was a barrier to change within the company; but also explained that their client's brief were mostly specified according to what they knew, which is the product they receive, which is made using the production floor. On one side, the company gives the clients what they ask. On the other, the clients only ask for what they are aware of, that they have been given. This situation therefore hindered the use of innovative processes (environmentally friendlier or not). This lack of requirements from the customer once again resonates with the findings from Boks and Pascual (2004), Lindahl (2005) and Luttrupp and Lagerstedt (2006) – previously explored in the literature review chapter.

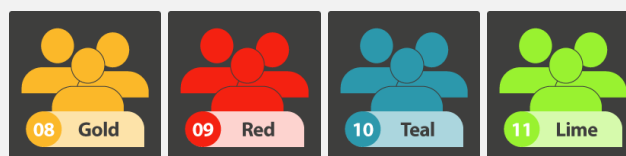
In **11-Lime**, the main design objective was to reduce the volume of the packaging for one of their products. However, it remained unclear whether this was an Eco Design objective, or simply an efficiency exercise. Another design objective was to use a transparent window on the packaging, so to enable the customer to see the contents. This objective had great implications in terms of Eco Design. It meant the use of two different materials, and of a way to bind the two materials together. Due to the added complexity, it was both a source of potentially greater expense and environmental impacts. The objectives were seen by the designers (**1103** and **1104**) and the quality assurance manager in charge of the project (**1101**) to be vague and, if not contradictory, at least conflicting. In the end, this conflict was handled by scraping the objective of a transparent window and by instead use the cheapest (and potentially greenest) solution, a plastic bag sized to its contents. Here the objectives (including the Eco design objectives) were badly handled. The design team was clearly unhappy with the outcome; not because of its merits (they admitted it was a good solution), but because of the lack of communication and collaboration by the main company (discussed in 'G. Communication and collaboration'). While it is clear the participants had difficulty during the process to work together to implement Eco Design; it is difficult to assess how much this situation only relates to the incorporation of Eco Design in the brief and how much

simply relates to Product Design. As mentioned above, the following corroborative stage of research will help provide further necessary insight.

Finding: There is a clear lack of Eco Design objectives in design briefs. The facilities and organisation of the main actors' companies hinder the implementation of Eco design objectives. If implemented in a design brief, Eco Design objectives seem to cause difficulties. Clients may be wary of added costs, production facilities are not interested in any alternatives that do not require their capabilities (fear to lose jobs), and design team may find difficult to achieve the demanded results in conjuncture with all other objectives. These findings lack validity due the nature of the funded projects followed and will be re-assessed in the next stage of research.

C. Adoption

This descriptive theme considers which (if any) Eco Design principles or approaches are either considered, or driving projects and the design process.



Present across all cases.

Although there is certainly an awareness of Eco Design amongst the case study participants; there is little done beyond the initial consideration. Environmental aspects are not usually part of the brief (as discussed in the previous theme); and the projects studied (especially in **09-Red**, **10-Teal** and **11-Lime**) do not fall in the realm of the main actors' usual practices. All cases included participants with clear (personal) empathy toward the environment (discussed in theme 'A1.

Ethics’); however this does not always translate in the adoption of Eco Design principles. The participants are all very driven to perform in the areas where efficiency and Eco Design meet (i.e.: savings on materials, processes, transport, etc...). This highlights an interesting question regarding Eco Design: should the adoption of efficiency measure be counted towards the adoption of Eco Design? Surely if Eco Design is about lowering impact on the environment without damaging the bottom line; then efficiency measures are part of Eco Design - at least from the cases studied so far. Is the difference that efficiency drives those changes rather than environmental concern? If so, that only seems a rhetorical issue rather than issue of actual adoption. Eco Design looks at reducing the environmental impacts of a product without damaging the bottom line. But companies seem to see this the other way around. They seem to not have the financial incentive to do so and rather prefer to reduce the economic impacts of their products while damaging less the environment if possible.

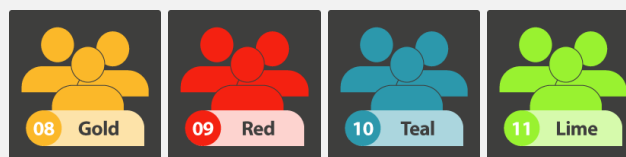
In **08-Gold**, showing to customers an adoption of Eco Design principles and presenting an environmentally friendly solution was seen to be a good selling point. This is what was driving the adoption; while in **09-Red**, **10-Teal** and **11-Lime**, the funding opportunity was the main driver (during the project) for the adoption of Eco Design principles. **09-Red’s** company director (**0901**) was really interested in investing more on Eco Design. However, none of the other projects in his company were adopting or working towards implementing Eco Design and it was rarely part of their clients’ briefs. In **10-Teal** and **11-Lime**, the economic savings that Eco Design could provide were the only driver or signs of Eco Design adoption.

This theme made an important part of the data gathered across the cases for different reasons. In **08-Gold**, it was because the company was publicly showing their intent to adopt Eco Design and because there was a product designer truly invested in the subject. In **09-Red**, it was because the company director had an internal struggle keeping business as usual. He wanted to find a way to make things better for the environment but could not manage to find an economic viability in Eco Design alternatives. In **10-Teal** and **11-Lime**, the rationale was to save money; their interest was to design as efficiently as possible, saving weight and space; which would in turn save on materials and fuel costs.

Finding: While these cases show a spectrum of types of Eco Design adoption, none portray the academic textbook process Eco Design adoption and implementation (as seen in section 2.3 and 2.4); specifically where Eco Design drives the design process and influences the design choices based on environmental criteria. Overall, Eco Design adoption is arguable and limited to efficiency measures.

D. Approaches

Collects the information on Eco Design approaches (including Eco-Tools) that had been given thought to. Also includes participants' views and opinions on the usefulness of those approaches.



Present across all cases.

As with the previous theme, this theme did not reflect the standard practices of the participants, but provided insight into how they could handle the implementation of Eco Design in one of their design projects. In **09-Red**, **10-Teal** and **11-Lime**, the funded projects that were investigated had artificially implemented Eco Design approaches through the knowledge and technical expertise of the Environmental Consultant (as described in section 5.1, Data Collection). The adoption of Eco Design in those three projects was very similar and is described below through the example of the case **09-Red**.

The environmental consultant's role was received positively across the three cases and their participants. The knowledge he brought to the companies

enabled them to ‘think outside the box’. However, a certain lack of realism and pragmatism from his part was mentioned. It was sometimes seen as if his choices were out of touch with the companies capabilities. **0905** explained the environmental consultant had found a good environmental alternative to their panelling material. On paper, it sounded great; but the replacement was only manufactured in the USA and on small scales. **0905** and **0901** felt this was simply not viable for logistical reasons; however good the product was. However, the environmental consultant did not seem to have knowledge of these problems. Across the cases, his services did extend to an involvement in the design process and its iterations; although his work was more a research exercise than collaboration with the actors engaged with the design process. As a result, the designers from the different cases expressed their reluctance towards the use of an environmental consultant, but also by extension towards Eco Design solutions (e.g.: **0904**, **1005** and **1102**). Unfortunately, some seemed to link the outcomes from the exercise to the lack of usefulness of Eco Design. It is interesting to note that Birch et al. (2012) and Short et al. (2012), present similar findings, explaining how practitioners are left unconvinced by the benefit of Eco Design approaches and their results, and therefore do not use them.

The Environmental Consultant brought new knowledge and ideas to the projects; but unfortunately did not have enough background knowledge of the companies to make the most sensible choices. And this brings on the real issue of the use of a consultant. The role of the environmental consultant was to use Eco Design approaches to prescribe environmental alternatives; not to enable the participants and the companies to assimilate and implement Eco Design approaches to then develop their own environmental alternatives. This is a lack of long-term vision which provides very little future autonomy to the companies involved. This aspect relates to the lack of inside knowledge (discussed in theme ‘E. Knowledge’) and lack of processes to sustain Eco Design implementation (discussed in theme ‘F. Sustaining Implementation’).

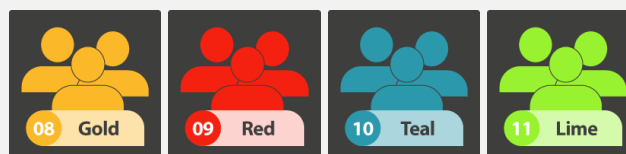
08-Gold was a much different case. The setup of the case followed a much more natural business organisation and it had a green champion and designer (**0801**) with Eco Design knowledge and a passion for the approach, *within* the design team. This set-up provided a lot of insight into how Eco Design can be

implemented internally. While **0801** found difficult to overcome the lack of interest or commitment from her colleagues, she was able to provide solutions fully tailored to the need of her team and company, with a much deeper knowledge of the organisation's needs and capabilities. She constituted both the environmental consultant and the designer; in charge of putting environmental alternatives through the design process to transform them in viable products. However, her departure towards the end of the data collection phase of this stage of research also hindered greatly the implementation of Eco Design. Alike with the environmental consultant in the other cases, her impact was limited to her presence.

Finding: The funding provided to the cases allowed for the implementation of Eco Design approaches through the use of an Environmental Consultant (see section 5.1). However, this approach did not seem to fully succeed in implementing Eco Design in the cases. The disconnection of the consultant (and its Eco Design approach) from the design process hindered the projects and the implementation on the long-term of Eco Design within the design process of the cases. These findings however have little validity outside of the cases and the next stage of research should help in this aspect.

E. Knowledge

Designers and teams' knowledge of Eco Design. How the knowledge is developed (e.g.: individually).



Present across all cases.

0903: LEDs are used because they offer low cost maintenance. I've heard they're not necessarily any less expensive to run.

09-Red's participants had little awareness of the financial cost (and even less of the environmental costs) of their designs. For example, when asked about the cost of delivering their units (manufactured in-house) per kilo of product or what was the amount of power used by, and life time of, the LED lighting compare to the fluorescent lighting they offered; no one had a clue. These aspects were at best guesstimated, but usually not even considered.

The lack of knowledge in quantifying both the environmental benefits and cost savings of alternatives (especially an Eco Design one) seems to be an important factor hindering their ability to implement Eco Design. This lack of knowledge within Eco Design is also seen by Lindahl (2005) as a hindering factor to the implementation of Eco Design. But more important than this lack of knowledge is the initial lack of importance placed on the potential opportunities. Approaching cost savings through Eco Design and the environment seems to bring reticence and suspicion or doubt (e.g.: **0802**, **0903** and **1005**). There seems to be a stigma on the abilities of Eco Design approaches to bring benefits to the environment without bringing more costs, work and time on themselves. This relates clearly to the theme 'A.3 Time and Trust' discussed above.

In all cases, there was evidence of certain 'materials habits' that has also been seen by Deutz (2013): designer are used to certain materials that they master. In **09-Red**, they mostly used MDF and joinery because their production floor had the production and design capabilities to work this material. This knowledge made them a very efficient company in their market. **0902** explained they were so efficient in designing their units that even though they had to respond yearly to tenders, they always won the contracts and were confident they would – as long as the briefs used their design and manufacturing forte.

This forte however brought on a negative aspect. All participants in **09-Red** describe how difficult it was to consider using other materials. **0903** simply said that his job was to feed the production floor (which was only really equipped for MDF joinery work). **0901** (director) was more inclined to the idea of changing materials

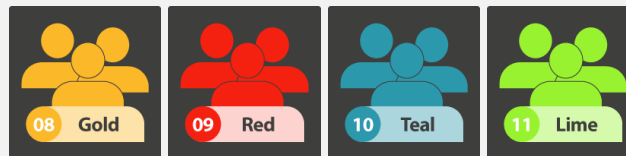
but explained the barriers to overcome were considerable and required changes to the core operations of the business (such as a change of staff in production).

In **08-Gold**, the Eco Design knowledge came mostly from their designer **0801**; her education and personal interests were driving the implementation. **0802** (design intern) felt this was not his area of expertise and explained he did not get involved with that. **0803** (design manager) also explained how she just did not have the time to develop this knowledge. **0905** (designer) did not feel it was his domain either. The participants across the cases were stating personal preferences as to whether they wanted to be involved in Eco Design. This feeling was reinforced by the personal language (relating to the individual's personality) used by the 'two sides' (pro-Eco Design and not invested). On one side, **0801** had clear personal investment, although it was part of her role to research such alternatives. She was happy to talk about the subject, help and displayed strongly emotions and opinions. **0804** (managing director) also had personal investment, and both he and his employees explained that it was "his thing"; as if it was only a personal curiosity. On the other side, **0802** (as well as for example **1001** and **1102**) showed a lack of interest in the conversation, providing short answer, and having generally little opinion on the subject.

Finding: There seems so far to be a link between the knowledge gathered and the personality or personal investment of the designer/individual. Across the cases, there was little belief in the value of learning about Eco Design and certainly no time/tasks set aside for this activity. This lack of knowledge within Eco Design is also seen by Lindahl (2005) as a hindering factor to the implementation of Eco Design.

F. Sustaining Implementation

How implementation is sustained, whether there are processes in place to drive further steps in Eco Design implementation.



Present across all cases.

Here, the theme emerged differently in **08-Gold** from the other cases. In all cases, there was a push to adopt Eco Design. In **09-Red**, **10-Teal** and **11-Lime**, this was done through a funded project. In **08-Gold** however, it was done through the employment of a product design graduate, **0801**, who was educated and personally invested in Eco Design. **0801** (designer) was pushing for Eco Design. She spent time creating and developing a materials library and researched ways to reduce internal operational waste. She also helped to implement ISO 14001 for the company before leaving the company. Her last interview was conducted a few months after her departure and the interviews conducted with her colleagues were carried out short after she had left. This enabled the researcher to find out what would happen to her work and whether there had been enough momentum to continue, without her, the implementation of an Eco Design approach. Unfortunately, it was felt that not much had remained. **0802** (design intern) expressed he knew only of that she had engaged in such activities, but did not remember anything specific. Regarding the materials library she created, the interviewer had to mention it for the intern to remember it existed and even then, he was not sure what or where it was:

Interviewer: *Do you know where it is now and what is happening to it?*

0802: *Is it in the back cupboard? [raising his shoulders]*

0804 (managing director) explained it was a shame the implementation had not been pursued and that it was a lack of time that was hindering the

continuation of Eco Design implementation. However, even before she left, **0801** encountered tough barriers to keep approaches implemented after initial adoption.

A good example of this was a story about the use of bamboo as an alternative material. It had required a great amount of energy from **0801** to manage to implement this Eco Design alternative. However, the energy was not great enough to make this Eco Design solution 'stick' for future projects. The other designers and the managing director would simply (using less energy) return to the normal state of using their traditional material (vinyl). **0801** emotionally described the great effort that had been needed to achieve this one success, while also expressing her despair when thinking about how it had not been enough to make it a permanent change.

In the other cases, the environmental consultant explained that these projects were a good opportunity for the companies to engage in Eco Design. However, one of the design consultants (**0905**) explained that they would need to shift this expertise in-house to make progress.

0905: They're all busy with daily tasks, although they do want to continue this project. If they really want to do it, then they should have a research and development team.

Interviewer: Weren't you, in some ways, the R&D team?

0905: Yes, but they need their own team to take ownership and implement this project because they don't have time to implement anything at the moment."

0901 (managing director) went even further, explaining they had no incentive to continue the project:

0901: If our client asked, then yes, we would. But if not, no. We're not bothered. There's no need to change directions when it's going well and no one asks for it.

It is interesting to denote **0901** is also the person the most committed to implementing Eco Design at his company. It plainly shows those contradictions between what can be assimilated as an individual point of view on what *should* be

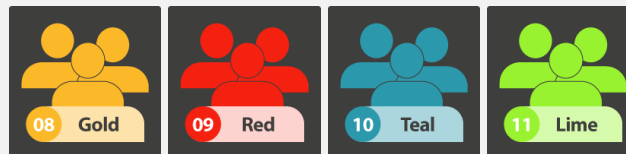
done and a business view of what *needs* to be done – even from the management level.

The issues encountered here show similarity with findings from Le Pochat et al. (2007) and Handfield et al. (2001) who also find lack of commitment to Eco Design knowledge (e.g.: through the use of an in-house expert) is great barrier to Eco Design implementation.

Finding: There is a lack of commitment to sustain Eco Design improvements, knowledge and generally implementation, ultimately failing to build on previous Eco Design efforts.

G. Communication and Collaboration

The (hindering or enabling) effects of Communication and Collaboration in the implementation of Eco Design. How Eco Design related information is communicated. How information is driven across teams and clients. How information is used in a collaborative way to improve the design process. How participants feel about communication and collaboration as being a potential issue to Eco design implementation.



Present across all cases.

This theme, unlike the previous ones, was not set up as an interview topic and came up during the data analysis stage. While the funding structure of **09-Red**, **10-Teal** and **11-Lime** makes it difficult to assess the external validity of this theme because of the cases' unusual organisation; recurrent occurrence of the theme

throughout all four cases shows potential for validity. The corroborative stage of research, presented in Chapter 6, will clear this uncertainty.

After a couple of meetings managed by **1103** (external project manager) and involving the design team and different stakeholders from the building goods merchants, **1102** (designer) realised those stakeholders only met for the project. They were unprepared; almost unaware of the project itself, they did not collaborate internally in between the meetings and had little to say during them. They came from different departments with different responsibilities and their knowledge and experience was a must for the project to be successful. However the lack of communication between them and the design team resulted in the project being ultimately abandoned.

In **10-Teal**, **1005** (external design engineer consultant) also expressed these problems. He expressed despair and felt resigned about the lack of communication within the project: *“there wasn’t much information to be honest... [...] it probably would have been good to gather knowledge with the other actors”*.

These findings resonate well with Coley's work (2008) investigating the implementation of an innovative design process and find the importance of developing partnerships and human interaction in such projects. Coley also identifies similar feelings of frustration in her interviews regarding the lack of communication and collaboration between parties.

0803 (design manager), asked about the potential use of a new material, nervously laughing: *“I’m not the right person to ask that question! [0804 (managing director)] might! Probably because we work through a stockholder and it involves more conversation. I say that, I may be wrong, we may be doing it and I’m not aware of the fact.”*

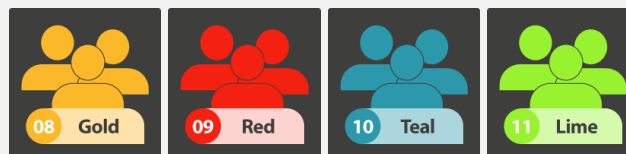
Lack of communication and collaboration has also been identified in the literature as an issue in regards to implementing Eco Design. In the context of Eco Design methods implementation, Lindahl suggests that *“interdisciplinary collaboration could be seen as a means to minimize missed communication, provide a broader knowledge base and increase the cross-fertilization of ideas”* (2005, p.44) and continues explaining that, *“designers’ degree of collaboration [...] has emerged*

during the research to be quite an important issue.” (Lindahl, 2005, p.44). As Deutz (2013) explains, this is however “*symptomatic of a deeper seated malaise*”. The problems of communication and collaboration do not originate from the implementation of Eco Design, but are found to be an issue across the design process itself. Petersen et al. (2005) express this point, explaining how communication and collaboration with the different actors of the product development stages is key to effectiveness and to raising environmental awareness across the product. The findings in the present research are similar.

Finding: There is a lack of information received by design teams that hinders the understanding and implementation of the Eco Design strategies. This lack of communication and collaboration at design teams and product development teams levels that, while not confined to Eco Design, hinders the implementation of Eco Design.

H. Economic Climate

The effect of the current and past economic climate on the adoption and implementation of Eco Design.



Present across all cases.

In this theme, participants talked about the developing economic recession and how it affected, in different ways, the implementation of Eco Design. This theme emerged during the interviewing process. Along the course of the research, the economic recession affected the design objectives of the projects studied and

the ways participants and their clients saw Eco Design. Economic climate is here seen as a major factor to the integration of Eco Design objectives in the design brief, and to ultimately the adoption and implementation of Eco Design in the design process.

In the literature, this theme is not yet fully documented, although some mention the effect of financial constraints on innovation and take on of Eco Design activities. The theme also relates to the issues of lack of time and trust reviewed in theme A3; although it is more specific to certain economic times. Both O'Hare (2010) and Deutz (2013) mention how lack of resources affect innovation; Deutz highlighting that: *"This greatly restricts the possibility of a solution that represents a significant break from current practice, which a truly sustainable solution is likely to be"* (p.127).

Participants, especially at the management level expressed how the current economic climate was hindering the implementation of Eco Design. In case **09-Red, 0903** (Production Manager) expressed his reticence towards the project itself for this same reason. He thought companies were not in a place to make big changes to their products (relating to innovation). Companies were open to design and manufacturing changes to create savings in the product, but not at the large expense of trial runs or time delays. This relates to the views of **0803** (Design Manager), who also felt her company did not have the room to afford design changes requiring prototyping and testing with potentially no conclusive results. In some ways, they described how the economic climate was hindering the opportunity to innovate and therefore to look at Eco Design alternatives. **0902** (Project Sales Manager) also referred to these economic climate factors, explaining how much easier it was to spend money on a project ten years ago. These changes were also evident in **11-Lime. 1101** (Quality assurance manager) explained that the project, which had run for two years, had been hit by the economic recession and that this had changed the original thinking and design focus. Environmental objectives were not part of the requirements anymore. By the end of this research stage, **08-Gold** was restructuring its business by dividing the company into two separate entities and letting go of some of their staff, especially in the design team (two out of the three interviewed designers had left the company and a fourth designer not interviewed was now freelancing for the company and others). At the

same time, **09-Red** had lost the client that the project was using as an example. The client, a major British brand had ceased their activities. In **10-Teal**, the manufacturing side of the business was gone and the business itself was operating with a minimum number of staff, under a new name. Finally, in **11-Lime**, the project had changed direction completely to choose the plastic bag option and shelf the design concept.

Finding: The current economic climate (recession of the late 2000's) is generally seen as hindering factor.

Conclusions

This stage of research explored Eco Design implementation across four cases, each having a project with Eco Design objectives. The cases varied in terms of the design industry and size of the case, as well as in terms of their Eco Design aims. The participants across the cases also differed greatly in terms of roles and experience. During this chapter, we explored the different themes, driving or hindering the implementation of Eco Design. We defined and contextualised these themes found in four cases with Eco Design intent across 23 participants. While this allowed to validate findings within and across the cases through the in-depth analysis of the participants' own point of view; it is difficult to conclude and generalise much outside of this set of cases. The next stage of research (presented in the following chapter) uses these findings as a basis of enquiry to either confirm, alter or deny them, and to allow external validity (generalisation). In regards to this stage of research, the findings are as follows:

A. Views: There is a general feeling that Eco Design is an important part of the product design process, but that it is in practice difficult to incorporate. There are feelings of frustration and cynicism towards the (lack of) implementation of Eco design, but also some indifference by some participants.

A1. Ethics: Some participants take Eco Design and environmental issues particularly to heart. They truly feel for the environment, and strongly believe in the need to do more as a society. These participants also show personal involvement, way beyond the requirements of their roles.

A2. Responsibility: Certain participants feel responsible for the production (direct or indirect) of their designs. Similarly to theme 'A1. Ethics', these participants feel the need to push for the implementation Eco design. Other participants dismiss Eco Design and responsibility in contributing to environmental impacts. This attitude seems to be a barrier to Eco Design adoption.

A3. Time and Trust: The fast-paced nature of the design process hinders Eco Design implementation, which requires time and resources that are not available. Designers have little to no time allocated to research on new materials and other innovations. This includes time to consider Eco Design alternative – let alone time to test or assess alternatives.

B. Objectives: There is a clear lack of Eco Design objectives in design briefs. The facilities and organisation of the main actors' companies hinder the implementation of Eco design objectives. If implemented in a design brief, Eco Design objectives seem to cause difficulties. Clients may be wary of added costs, production facilities are not interested in any alternatives that do not require their capabilities (fear to lose jobs), and design team may find difficult to achieve the demanded results in conjuncture with all other objectives. These findings lack validity due the nature of the funded projects followed and will be re-assessed in the next stage of research.

C. Adoption: While these cases show a spectrum of types of Eco Design adoption, none portray the academic textbook process Eco Design adoption and implementation (as seen in section 2.3 and 2.4); specifically where Eco Design drives the design process and influences the design choices based on environmental criteria. Overall, Eco Design adoption is arguable and limited to efficiency measures.

D. Approaches: The funding provided to the cases allowed for the implementation of Eco Design approaches through the use of an Environmental Consultant (see section 5.1). However, this approach did not seem to fully succeed in implementing Eco Design in the cases. The disconnection of the consultant (and its Eco Design approach) from the design process hindered the

projects and the implementation on the long-term of Eco Design within the design process of the cases. These findings however have little validity outside of the cases and the next stage of research should help in this aspect.

E. Knowledge: There seems so far to be a link between the knowledge gathered and the personality or personal investment of the designer/individual. Across the cases, there was little belief in the value of learning about Eco Design and certainly no time/tasks set aside for this activity. This lack of knowledge within Eco Design is also seen by Lindahl (2005) as a hindering factor to the implementation of Eco Design.

F. Sustaining Implementation: There is a lack of commitment to sustain Eco Design improvements, knowledge and generally implementation, ultimately failing to build on previous Eco Design efforts.

G. Communication and Collaboration: There is a lack of information received by design teams that hinders the understanding and implementation of the Eco Design strategies. This lack of communication and collaboration at design teams and product development teams levels that, while not confined to Eco Design, hinders the implementation of Eco Design.

H. Economic Climate: The current economic climate (recession of the late 2000's) is generally seen as hindering factor.

Chapter 6 - Corroboration Stage

This chapter is the third of three research chapters. It develops the findings presented in the previous chapter to verify the existence of the themes and to allow for their generalisation across the British Product Design industry. It presents the findings from the Corroborative Stage of research, a larger cross-sectional study of nine cases across twenty participants. The chapter first presents new methodological considerations, then the nine cases, the analysis of findings and discusses the different ways the themes appeared and confirmed the results from the previous stage of research. In the last section (6.5), this chapter presents the overall methodological reflection that resulted from undertaking the different stages of research.

Introduction

The aim of this stage of research is to confirm and fine-tune the themes explored previously. This will enable the research to generalize the gathered knowledge to a larger extent by exploring cases covering a large percentage of the population. This stage of research used a cross-sectional study methodology through semi-structured interviews. Over 80% of product design consultancies in terms of British market share were interviewed (Relph-Knight, 2011). Nine small and medium enterprises took part, resulting in 21 interviews with 20 interviewees. Like the previous research stage, interviews were undertaken where possible with designers, engineers, production managers and managing directors on their current and recent Eco Design related projects. This stage of research enabled the gathering of a greater variety of findings through the use of a greater number of

cases and participants. The use of a larger sample size and of comparative cases from different settings enabled this research to corroborate patterns of association and therefore to offer potential for contextualised generalisation and theory building. This high generation of findings also allowed to reach data saturation without using too much resource from each case participant in an industry where time is very precious. The interviews provided a rich and personalised picture of distinctive cases. Each participant offered a personal account grounded in their different backgrounds and position in the company. They were guided by the researcher through the introduction of broad questions, grouped into topics (identified in section 5.1) as well as on the themes that emerged in the previous stage of research (see section 5.3). The use of broad, open-ended questions, allowed the participants more freedom to express their views (Bryman, 2008).

6.1 Methodology

This chapter presents the analysis of the data collected on nine cases and analyses the challenges faced when implementing Eco Design; describing the experiences lived by 20 participants. This information was collected and analysed using a methodology explored and described in chapter 4 and section 5.1. This section below presents the methodological context and changes that formed this stage of research.

Data Collection

Following a similar process to the explorative stage of research (see section 5.1); certain changes in terms of focus were to reflect the depth vs breadth emphasis of this stage of research. While the previous stage focused on depth within a small amount of cases (a comparative case study design); this stage of research focused on breadth of cases to validate the findings from the former stage

of research (a cross-sectional study design). While the themes developed in the previous stage of research guided the investigation during this stage of the investigation; similar discussions with open-ended questions took place to ensure no themes had been missed. The revised themes, containing the discovery of new or amended themes from this stage of research, are presented in section 6.3 before their analysis in section 6.4.

Thematic Analysis

While the process of thematic analysis remained the same; this stage of research based the investigation on an existing set of themes. Therefore, the analysis was primarily focused on evaluating the presence of themes and corroborating existing findings. While keeping an eye open for new themes, the analysis evaluated the occurrence of themes through the same coding process described in section 5.1. While the previous chapter presented in-depth narratives to help understand the unearthing of codes and thereafter themes; this stage of research directly presents the thematic analysis in section 6.4.

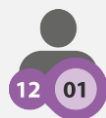
6.2 The Cases

This section introduces each of the nine cases investigated during the Corroborative Stage of research. It presents a short background for each of the cases and their participants that in turn help to contextualise the comparative analysis presented in section 6.4.



12-Purple is composed of two entities: a large multinational chemical company based in the UK and a university research group in textile materials engineering. The main company specialises in the manufacture of adhesives and resins and employs over 600 people. The investigated design project looked at developing a replacement for glass-fibre reinforced composite, using natural materials. The project's actors were clearly engaged in lowering the environmental impact of a product, and in this sense were found to be adequate for this research. However, the project fringed onto the realm of research and development rather than straight forward product development with immediate commercial application. This is taken into account during the analysis of the findings, and the differences in used approaches highlighted. The participants were also interviewed on past and other current projects to gather a better understanding of their overall design activities.

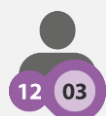
The case consisted of 3 Participants and 3 Interviews.



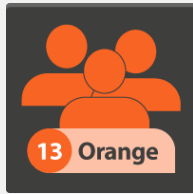
Senior Applications Engineer
Environmental champion of this project, expert in resins and composites



Researcher
Worked on the fibre side of the composite



Project Manager
From the university research group



13-Orange is a small retail design company. They provide point of sales and retail fixtures, including electronic devices to large companies. The company designs in-house but relies on suppliers for manufacture. Here, the study looked at all aspects of the design projects, probing the different participants on all current and past projects. The study came at a time in the company where there was an internal push to develop Eco Design expertise, due to an increase in demand from their customers.

The case consisted of 3 Participants and 3 Interviews.



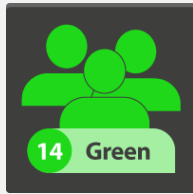
Graphic Designer
Environmental Champion



Product Designer



Operations Manager



14-Green is one of the leading and largest product design consultancies in the UK. The company ranks amongst the top ten design consultancies (Relph-Knight, 2011). The consultancy provides product design, research and engineering services within several industries, including medical products, electronics and fast moving consumer goods (FMCG). The confidentiality nature of their design projects made it difficult to explore in depth specific examples. 1402, one of the product designers, expressed she felt unable to tell the interviewer any details: *"I feel there is a barrier here because I cannot give you the information"*.

The case consisted of 3 Participants and 3 Interviews.



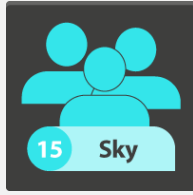
Senior Product Designer



Product Designer
Environmentally engaged



Product Designer
Green Champion



15-Sky is another of the leading and largest product design consultancy in the UK. The company also ranks amongst the top ten design consultancies (Relph-Knight, 2011). This was a very difficult case to access. Potential participants expressed they were too busy to spend time on interviews that not bring them any value. Even after participants accepted to be interviewed, they were generally unhappy to have to do so and expressed little interest during the interviews. Questions were geared towards what they felt about the workflow of their company, which helped generate interest to talk. However, they felt distrust towards the anonymity of the research process and feared any details that could identify themselves or a particular design project. This is also a trait that was present in 14-Green.

The case consisted of 3 Participants and 3 Interviews.



Senior Product Designer



Product Designer



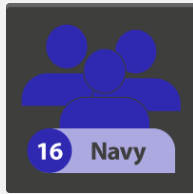
Design Director

All participants were asked about their environmental strategies. All responded that they were in the process of bolstering capabilities in that area but that they could not talk about specifics. The whole affair was treated as an

industrial secret they could not divulge. It seemed the ‘capabilities’ entailed the hiring of an environmental consultant. While the consultant had provided services to this consultancy in past, it seemed the company was about to invest in an in-house environmental expert. **1501** explained: *“This is confidential for political reasons. Environmental consultants have always been there; but in the last five years, interest from the clients has peaked.”* After the interview ended and the recording stopped, **1501** actually divulged more information about the consultant’s hire (written notes were taken after the meeting ended). Bryman (2008) explains such situations are commonly found by interviewers. Indeed, interviewees sometimes do not feel comfortable to express sensitive information on record, but will after the end of the recording, be more talkative. The consultancy, or at least the participants, seemed scared by internal politics. Many frustrations about the design process and the dynamics and workflow of the company was explained by *“political reasons”*. At the time of interviewing however, there did not seem to be much Eco Design capabilities in-house, nor did it seem to be anyone leading further the environmental agenda:

Interviewer: *Is there anyone more than the rest pushing the environmental agenda?*

1501: *No. It is difficult for me to talk to you about this area, because there isn’t really any environmental action in the company as whole. We talk about it, but we’re not in a position to drive it, we’re only able to guide. We’re an innovation consultancy, but environmental innovation isn’t really happening with the types of clients we’re involved in. Usually, this is more taken on by a specialist company that make sustainability their unique selling point. How could we take this on board to benefit our clients? As a company, I don’t think we’re at a point where we’re structured enough to have a corporate view of how to approach sustainability.*



16-Navy is a small product and engineering design consultancy. Here, all projects and potential Eco Design elements were consulted, including any aspects relating to materials efficiency, recyclability, and so on.

The case consisted of 1 Participants and 1 Interviews.



Product Design Manager

In some cases, like this one, very little is done in terms of Eco Design. While this case is a small design consultancy of four employees, it is hard to say whether there is a link between the size of the business and the lack of Eco Design thinking and demand. Regardless, this case generated very interesting data in terms of design principles and workflow in small design consultancies, but little data on any of the themes previously identified, or new even new themes relating to Eco Design implementation. This *lack of* consideration of Eco Design therefore only relates to the theme 'Objectives'. However, the lack of Eco Design in this case is important because it frames the landscape of Eco Design in the British Product Design Industry.

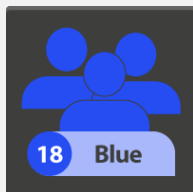


17-Crimson is one of the largest product design consultancies in UK. Here again, the availability of the personnel was low and only one of the director was interviewed; no one else was available due to time constraints and what seemed to be a lack of trust - developed below in the comparative analysis. However, from his senior position within the firm, having worked for many years in the consultancy, the director was able to provide great insight on the company, its clients and employees.

The case consisted of 1 Participants and 1 Interviews.

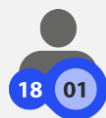


Design Director
Senior position

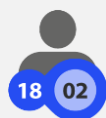


18-Blue is a multinational manufacturer of office furniture. They are renowned for their environmental policies and designs. Here the research was able to access to two participants and discuss both current and past projects.

The case consisted of 2 Participants and 2 Interviews.



Design Engineer

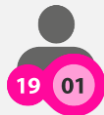


Senior Marketing

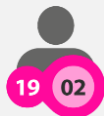


19-Pink is an SME designing and overseeing the manufacture of office light systems. Here, the Eco Design elements and the need for Energy saving products are two objectives which can be hard to distinguish. The company marketed the efficiency of their designs, reducing energy use and heat in the lamps (reduced heat also increase the product's longevity. The Design Engineer (**1901**) was the main person in charge of the design and engineering of the company's products and was also very knowledgeable on energy-using products legislation and lighting in buildings regulations.

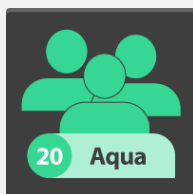
The case was made of 2 Participants along 2 Interviews.



Design Engineer



Product Designer



20-Aqua is one of the other large design consultancies in the UK focusing on electronic products. The company ranks amongst the top ten design consultancies (Relph-Knight, 2011). While the participants' availability was low, the interviewed participants were happy to provide time for long interviews, each lasting over an hour.

The case consisted of 2 Participants and 2 Interviews.



Senior Product Designer



Product Designer

6.3 The Themes (Revised Version)

In the previous chapter, during the explorative stage of research, an initial list of themes was identified from the case study's findings. This section redefines those themes unearthed in the explorative stage of research, revised in light of the findings from the corroborative stage of research. The next section then presents the data behind the thematic and comparative analysis undertaken across the cases.

For this final stage of research, the aim was to confirm the findings from the previous stage and to do so keeping an open mind for potential new insight (i.e.: new themes). There also remained a great interest in hearing about the stories and experiences the participants had gone through. As a result of the thematic analysis, one new theme emerged and another was modified in light of new findings. The other themes remained largely unchanged, and were mainly fine-tuned by the new findings.

The new theme that emerged during this stage of research relates to how Eco Design is viewed by practitioners as a part of 'good design' practices. **0907** had originally mentioned this during an interview, but it had been dismissed due to a lack of reoccurrence. This is a finding that is also seen in literature: *"For some designers, these practices are simply becoming part of good design"* (Design Council, 2010).

Good Design

Eco Design is seen as a part of what is considered 'Good Design' and link Eco Design pragmatic objectives simply as 'efficiency'.

Then, new findings emerged surrounding the theme 'F. Sustaining Implementation' (from the explorative stage) that shed a new light on the pertinence and boundaries of the theme. It became clear that the difficulties (or opportunities) of sustaining Eco Design implementation related mainly to

transferring knowledge from one employee to another or one company to another. The theme was therefore adapted to reflect this and further thematic analysis took place to identify knowledge transfer related data across all cases of this stage of research.

F. Sustaining Implementation (Explorative Stage)

How implementation is sustained, whether there are processes in place to drive further steps in Eco Design implementation.



F. Knowledge Transfer (Corroborative Stage)

How implementation is sustained, whether there are processes in place to drive further steps in Eco Design implementation.

Following the coding of the data during this stage of research and the changes made to the definition of the themes; the revised version of the themes is presented on the following two pages.

A. Views

Whether Eco Design is seen positively or negatively. This theme covers the interviewees' personal opinion on the discipline in the context of their industry.

A¹. Ethics

This theme considers the personal engagement of interviewees in environment issues. It describes the environmental investment of some of the participants, how some felt that they were the 'Green champions' of their teams/company and that dealing with environmental issues was about doing 'the right thing'. The theme also encompasses note-worthy, opposite views.

A². Responsibility

This theme groups the views of the participants on their sense of responsibility vis-à-vis of Eco Design implementation. It considers their feeling of Eco Design implementation being: out of their personal/company control, not part of their own responsibility, not asked for, uncared for because of the way markets are organised, etc.

A³. Time and Trust

Lack of trust in the available environmental information and environmentally friendlier materials/designs, and lack of time to investigate, undertake research. Fear of doing the wrong thing, fear it could backfire.

A⁴. "Good Design"

Eco Design is seen as a part of what is considered 'Good Design' and link Eco Design pragmatic objectives simply as 'efficiency'.

New Theme

B. Objectives

Whether and how environmental objectives (Eco Design objectives) are part of the design brief. Also regards environmental objectives that are conflicting with other design objectives.

C. Adoption

This descriptive theme considers which (if any) Eco Design principles or approaches are either considered, or driving projects and the design process.

D. Approaches

Collects the information on Eco Design approaches (including Eco-Tools) that had been given thought to. Also includes participants' views and opinions on the usefulness of those approaches.

E. Knowledge

Designers and teams' knowledge of Eco Design. How the knowledge is developed (e.g.: individually).

F. Knowledge Transfer

How implementation is sustained, whether there are processes in place to drive further steps in Eco Design implementation.

G. Communication and Collaboration

The (hindering or enabling) effects of Communication and Collaboration in the implementation of Eco Design. How Eco Design related information is communicated. How information is driven across teams and clients. How information is used in a collaborative way to improve the design process. How participants feel about communication and collaboration as being a potential issue to Eco design implementation.

H. Economic Climate

The effect of the current and past economic climate on the adoption and implementation of Eco Design.

6.4 Comparative Analysis

While the previous section presented a revised version of the defined themes, this section provides a comparative analysis of the occurrence of the themes across the cases, and its findings. Similarly to section 5.4, it provides with the aid of interview quotes and short stories, the analysis of the data collected across the cases.

The following comparative analysis explores the various ways in which each theme occurs across the cases, how the themes are seen by each participant of the same case, and allows the reader to understand the different consequences each theme can bring for different cases. These consequences can be seen as having a positive or negative effect on Eco Design implementation and can be defined as potential drivers or barriers to that implementation. Each theme is discussed in turn, using short narratives, quotes and description and looking at the occurrence and frequency of occurrence of the theme, providing for conclusion, the key findings of the theme for this stage of research.

A. Views

Whether Eco Design is seen positively or negatively. This theme covers the interviewees' personal opinion on the discipline in the context of their industry.

Findings from the previous explorative stage (section 5.4): There is a general feeling that Eco Design is an important part of the product design process, but that it is in practice difficult to incorporate. There are feelings of frustration and cynicism towards the (lack of) implementation of Eco design, but also some indifference by some participants.

While the views of the participants can generally be summarised as being either positive or negative, a driver or a barrier to Eco Design implementation; the findings from this theme show lots of conflicting and spread of opinions within cases, revealing a much more complex image on how Eco Design is viewed in design teams.

On one side, there were clear-cut 'green champions', advocating, as in the previous research stage, the need to implement Eco Design. These green champions, such as **1301** (graphic designer), **1402** (product designer) and **1802** (senior marketing) were all very vocal about the need to do more, both during the interviews and during their day-to-day roles.

On the other side, there were a few participants with very-low opinions of Eco Design. The almost 'non-politically correct', indifferent opinions displayed in interviews show how comfortable they were to share these opinions, maybe due to the anonymity of the exchange. **1701** (design director) showed lack of concern and cynicism towards the discipline and aspects of our society caring for the environment: *"it's ok for Marks & Spencer to say they've reduced their packaging for their customers, but it's well known they've increased it to decrease it"*. According to him, interest in environmental issues within his design team was only something the young generation empathised with. **1501** (senior product designer) similarly felt the younger generations of designers within his design consultancy

emphasised more with issue than older generations. **1402** (product designer) also shared this view. While the sample of interviewees was too small to develop a clear understanding of the differences of views between generations; the combined views of the interviewees, especially in design consultancies, showed that the younger and more junior the roles (**1301, 1402, 1403, 1502, 1902, 2002**), the more empathy towards Eco Design there was in design teams.

Then, similarly to the previous stage of research, there was an array of participants mostly sympathetic to the issue but feeling powerless:

***1401:** I've been to China, I've seen the way they make things, to be honest with you: it fills me with horror. But, I'm hoping there is more legislation coming, in terms on recycling and all that sort of things.*

***1502:** The difficulty with this topic is always about measuring. At the moment, there is no sense of measurement, of what's good, what's bad. That's a nightmare. So you use marketing to lead the positive and suppress the bad things.*

These participants blamed a lack of demand from their clients, a lack of enforcing legislation, and the difficulty of measuring and proving actual environmental benefit. They feared to “*get it wrong*” (**1502**) and to endure a backlash or to “*get it perfect and go out of business*” (**1901**).

Most participants also felt Eco Design would ‘lift off’ in the coming years, but did not see at the moment enough demand to warrant more attention. This was not the case in **18-Blue**, which was the only case claiming to have Eco Design at the core of their business. However, while **1802** (senior marketing) expressed the importance of Eco Design for the company, **1801** (design engineer) explained: “*The environmental interest is not there when it comes down to it. It's a box ticking exercise; it's mostly all about price*”. While the company operates with stringent materials and processes restriction (based on environmental criteria); the design process follows cost-efficiency as its top criterion. This shows that even in a case where Eco Design is considered of fundamental importance, the design team is not included in the stage of the product development process that adopts an Eco design process: the environmental elements are prescribed to them by management (in

the form of a restricted list of materials and processes); and their design work remains focused on the economic bottom line.

Finally, it is interesting to note some cases in this stage of research where less involved and interested in Eco Design, and therefore presented less opinionated views. This included case **16-Navy**, which did not see the relevance of Eco Design in their work, where it simply did not occur.

Finding: While the age of the respondents was not recorded during the research, there seems to be a generational factor in how Eco design is viewed. Younger generations (and more junior job roles) empathised much more with environmental issues, with a couple of exceptions. Participants generally wish more was done in Eco Design but feel powerless due to external factors.

A¹. Ethics

This theme considers the personal engagement of interviewees in environment issues. It describes the environmental investment of some of the participants, how some felt that they were the 'Green champions' of their teams/company and that dealing with environmental issues was about doing 'the right thing'. The theme also encompasses note-worthy, opposite views.

Findings from the previous explorative stage (section 5.4): Some participants take Eco Design and environmental issues particularly to heart. They truly feel for the environment, and strongly believe in the need to do more as a society. These participants also show personal involvement, way beyond the requirements of their roles.

When approaching companies for this research, the 'green champions' were the most receptive to the need for the research and sympathetic in providing time for interviews. Therefore, the research sample potentially contains more environmentally-inclined and aware participants than a random sample. However,

not all companies involved in this research either contained green champions (or these were not made known to the research). Several cases do not include any participants that can be deemed as containing a green champion, especially within those cases that showed little interest in Eco Design (such as **15-Sky** and **17-Crimson**). Overall, a majority of the participants neither counted themselves as green champions nor engaged in Eco Design, and were simply apathetic to the topic.

Cases **13-Orange** and **14-Green** contained the strongest examples of green champions. In **13-Orange**, **1301** (graphic designer) led all environmental efforts. He expressed lots of sympathy for environmental issues and embarrassment about the impacts of his company. Similarly to other cases across both research stages, he took on the initiative of leading an environmental strategy for the company, although it wasn't part of his job description. This 'crusade' to convince his colleagues and management to embrace Eco-Design and sustainability was a personal one. **1303** (operations manager), and product designers **1402** and **1403**, talk of their Eco Design aspirations, beliefs and about how the environment is part of everything they do.

***1303:** I wouldn't say I'm an eco-warrior but I'm truly a believer. I think like that all the time.*

This is a decisive element in this theme: sympathy for the environment is not a feeling or interest that is limited to daily work tasks, but to the daily life of those participants. It sometimes comes with some frustration towards the lack of receptiveness from clients. Talking about how she felt entering her current position, **1402** explains:

***1402:** I think that it is scary that clients don't come in and ask us about it. I assumed they would be loads asking about how to be green.*

And confronted with the distant attitude towards Eco Design expressed by their clients, these green champions respond in very different ways to the rest of the participants:

Interviewer: *Do you think Eco Design is more expensive?*

1301: *Yeah. But we want to do it.*

1501: *We try to push companies to look at environmental issues, but we can't keep doing that. At the end of the day, they're the ones paying us. We could keep pushing, but we wouldn't have any clients left then. [...] We would like to be seen as responsible, and when we are asked to do something that is inexcusable from an environmental point of view and we feel it's excessive, we will push to their CSR [Corporate Social Responsibility] policy or conscience. But at the end of the day, if they still want it, that's pretty much all we can do.*

When asked about barriers to Eco Design, green champions focused on a lack of time or resources. They also put a lot of the responsibility for Eco Design implementation on themselves personally. The other participants, on the other hand, focused on the lack of demand from their clients or the lack of proof and fear to be wrong. Finally, the environmentally-sensitive participants also expressed how they wish they could do more, how they wish they could tell the research they did more, and that they felt bad this was not the case.

2002: *Personally, I want to do the right thing [...]. I always feel bad in a way. I'd like to be able to say we are doing an environmental project or such. But the simple reality is that the view of environmental design for client is just about ticking boxes, in the same way they have to tick safety boxes.*

Finding: 'Green champions' believe more should be done and personally feel for the environment. They are personally involved, not only at work, but during their daily lives. They are evangelists within their design team and company, and take on projects on personal time to improve the Eco Design implementation of their company. This is balanced by a vast majority of designers apathetic to the issue, either voicing their lack of interest or their lack of leeway to choose to approach the issue (see next theme, 'A2. Responsibility').

A². Responsibility

This theme groups the views of the participants on their sense of responsibility vis-à-vis of Eco Design implementation. It considers their feeling of Eco Design implementation being: out of their personal/company control, not part of their own responsibility, not asked for, uncared for because of the way markets are organised, etc.

Findings from the previous explorative stage (section 5.4): Certain participants feel responsible for the production (direct or indirect) of their designs. Similarly to theme 'A1. Ethics', these participants feel the need to push for the implementation Eco design. Other participants dismiss Eco Design and responsibility in contributing to environmental impacts. This attitude seems to be a barrier to Eco Design adoption.

While this theme is similar to the findings in A1, it differs in that it relates to how participants view the impacts of the design and production of the cases, rather than personal opinions and feelings on the environment. During this stage of research, the sense of responsibility of participants and cases was seen to be directly influencing Eco Design adoption and implementation. Low responsibility in turn reduces the visibility of Eco Design in the design process and creates a barrier to Eco Design adoption and implementation. Participants with a high feeling of responsibility showed they promoted Eco Design to their teams and clients, therefore helping drive Eco design. There also seems to be a lack of responsibility in design consultancies. **14-Green, 15-Sky** and **17-Crimson** (design consultancies) all expressed environmental impacts were out of their control, and that those decisions were up to clients; which were either not interested or did not ask about Eco Design. The table below presents the different views expressed across the interviews. They range from positive to negative feelings of responsibility vis-à-vis of the impacts of their design choices and production.

Positive / Driver Sense of responsibility.	
<p>1501 <i>I'd like to promote it [Eco Design], but that's not what we do, we can suggest it, but that's all. A lot of the times, clients we have in contact have lower levels of decision, it's above that those decisions are made.</i></p> <p>1502 <i>We advise, say 'you should do that', influence companies, connect to senior management, work with marketing; but their shelf life is 18 months before they move jobs, so we need to be more connected to board level to influence change.</i></p> <p>1401 <i>If we were doing something specifically sustainable, we'd look at where it's made, the materials, etc. But the client does not pay us for that.</i></p> <p>1701 <i>[interviewer] Do they ask u for advice? Not really, we work with sales people and marketers. They already have a strategy established. Generally our customers don't even talk about it.</i></p> <p>1901 <i>As long as they're over the regulation level, they're happy. Our clients don't care what happen to fittings [lights] after they've installed them in shops. We try do less parts, but that's to keep costs down, not for environment reason; although it'd be nice.</i></p>	<p>1403 <i>A lot of people don't know where or how to start in industry, but here we have people like me that can help.</i></p> <p>1403 <i>What would be fantastic is if it was driven from the top. Either [our design consultancy] dedicating a budget to it, or clients coming and asking for it. It's difficult because we're a consultancy, we work for others and we don't decide what they should spend their money on. I think it is coming though, the sustainability culture; but it has not been transposed yet on what it means and how to do it. I wonder how we can keep the ball running to make people go for it.</i></p> <p>1901 <i>There are legal requirements asking for lights to get more and more efficient. The problem is that of the initial cost of the LEDs. There's always an installation and a separate running budget. They're not seen together. [...] Although we can prove to them they can make their money back, they're not the same employee that is in charge of running costs.</i></p> <p>1401 <i>Because ultimately, it's down to the client. We can suggest things, but hmm, sustainability is really something they have to ask for; because obviously, we are a consultancy and we have to get paid for the hours we get involved.</i></p>
No sense of responsibility. Negative / Barrier	

Table 6.1 – Examples of the sense of responsibility expressed across the cases.

Finding: Most designers feel the responsibility to engage on Eco Design ultimately lies with their clients. Certain participants feel that because this is the case, clients have to ask them to work on Eco design for them to consider the issue. Other participants with higher feeling of responsibility vis-à-vis of the environmental impacts of their designs showed greater involvement in pursuing Eco Design both personally and by trying to involve colleagues and clients.

A³. Time and Trust

Lack of trust in the available environmental information and environmentally friendlier materials/designs, and lack of time to investigate, undertake research. Fear of doing the wrong thing, fear it could backfire.

Findings from the previous explorative stage (section 5.4): The fast-paced nature of the design process hinders Eco Design implementation, which requires time and resources that are not available. Designers have little to no time allocated to research on new materials and other innovations. This includes time to consider Eco Design alternative – let alone time to test or assess alternatives.

The basis for this theme strengthened during this second stage of research. The vast majority of cases expressed a lack of time to research and trust Eco Design as a major barrier to Eco Design implementation.

1701: [Our clients] are too worried they'll get it wrong. [...] They cannot afford to jeopardise their marketing message.

As **1501** explains, there is a reluctance to adopt Eco Design alternatives that is linked to the confusion as to which environmental aspects to prioritise. Clients and designers fear that making a reduction in one measurement of an environmental impact (e.g.: CO₂) may lead to other unforeseen environmental impacts, making the product overall worse for the environment. Clients then also

fear the marketing claims from these Eco Design approaches may backfire. Participants in the majority of cases cite the lack of priority on what to work on, and the lack of possible like-for-like comparison of products:

1501: Is it better to use card rather than plastic? Or recycled materials? Or recyclable materials but raw materials? Or just lower CO2?

1701: We've talked about pouch packaging, but sandwich materials are not recyclable, so maybe more material is better if it is recyclable. Then we are talking about biopolymers, but there is no interest yet, and therefore problems of supply and availability...

In all, designers and clients are confused and afraid to do the wrong thing. They mistrust Eco Design approaches and alternatives, and prefer not to engage with it.

Then, most cases talked about a linked issue to this lack of trust: a lack of time. As in the previous stage of research, they explain they lack the time to investigate Eco Design approaches and alternatives because of a lack of trust in the discipline and in its advantages. It is a catch-22, where a lack of trust hinders the allocation of resources on investigating Eco Design and a lack of investigation hinders the possibility to trust and adopt Eco Design. They also lack the time to research and investigate not only on Eco Design, but more broadly on all types of innovation; a finding that relates to that of O'Hare (2010).

18-Blue was an outsider in relation to this theme. The company spent large amounts of resources on researching Eco Design materials and alternatives, as well as assessing their products on an extensive range of environmental criteria. However, their core business area being to provide Eco Design alternatives for furniture, it explains their unique situation in this theme.

The table below presents quotes from participants on this theme and how a lack of time and trust hinder the implementation of Eco design.

Barrier	
Lack of time to devote to Eco Design and trust in Eco Design alternatives.	
<p>1302 <i>Eco design is associated with being expensive.</i></p> <p>1302 <i>Not many clients take leap of faith for something new.</i></p> <p>1401 <i>Seems as if when you say sustainability, you scare people off; but light, minimal is good.</i></p> <p>1403 <i>I had an aspiration to make it company-wide, adapt it with prompts and guides. There is no time yet to do it.</i></p>	<p>1501 <i>CO2 is a recent thing, I'm not sure. It's more of a due diligence thing. There's a number of companies able to do that, but the problem is that I have with those is that I found different results on same comparisons. Most people using these comparisons are manufacturers, and therefore biased. There are too many different lenses on how to look at it.</i></p> <p>1501 <i>It's a complex area, if I spent my whole time trying to work out what the best thing to do is from an environmental point of view, we would not actually get any work done. When we have to become environmental experts, we'll get someone solely employed on environmental issues. But it's not where our focus is.</i></p> <p>1801 <i>We create a huge amount of [Eco Design] information. We then have to express it into sizeable chunks.</i></p>
<p>Dedicated time to researching and assessing (trust) Eco Design alternatives.</p> <p>Driver</p>	

Table 6.2 – Examples of participants expressing their lack of trust and time.

Finding: There is a clear lack of time to research Eco Design amongst design teams and a lack of trust in Eco Design alternatives. The industry is wary of making marketing claims on the environmental benefits of Eco Designed alternatives without tangible undeniable proofs and the lack of standardised environmental assessment.

A⁴. “Good Design”

Eco Design is seen as a part of what is considered ‘Good Design’ and link Eco Design pragmatic objectives simply as ‘efficiency’.

New Theme

1403: We don’t actively do Eco Design, but we try to do good design, and that’s a natural part of it.

As developed in section 6.3, this theme was only unearthed during this stage last stage of research and suggests a stigma about what Eco Design involves. Eco Design does not resonate well with clients, and is often associated with extra cost (see respectively theme A3. Time and Trust and H. Economic Climate).

1302: Eco design is associated with being expensive.

On the other hand it seems that when discussing specific projects and using descriptive vocabulary rather than the name of the discipline itself, the reaction from both participants and their clients is always much more positive:

1401: It seems as if you say “sustainability”, you scare people off. But “light”, “minimal” is good.

While talking about specific projects, the interviewer teased out Eco design elements, such as material or energy efficiency. Participants often expressed these were usually taken into account and simply part of what they called ‘good design’ principles:

Interviewer: *Do you feel becoming more efficient is becoming more Eco-friendly?*

1402: Definitely. There’s a set of good design principles that make things better environmentally. Although lowering environmental impacts is not the first thing in the brief.

Other participants explained the same phenomena, with different terms.

1301 explained how they used “value engineering” (where value is the ratio of

function to cost) and how they felt this also reduced environmental impacts of their products through efficiency. **1401** explained how for the sake of profitability, Fast Moving Consumer Goods (FMCG) were essentially designed to be as efficient as possible. However, he also explained that this does not necessarily means it will be the most environmentally-friendly option:

1401: On the FMCG side, regarding material usage, we use as little as possible anyway and they are recyclable anyway. For their own profitability, they tend to be very efficient on transport, manufacturing, and etcetera. I'm not saying they're environmentally friendly companies, but... [...] From a design point of view, you are always going to try to use as little plastic as possible. But you often design to a cost: if we have a more environmentally-friendly material that is made in Europe, you can bet the client is not going to choose that over a cheaper material that has probably been made in a very bad way.

Finding: Vocabulary is important when discussing Eco Design. According to Design Teams' experiences, terms directly relating to the environment inspire fear and added cost to clients, and to designers to a lesser degree. But talking about the effect of Eco Design, such as light-weighting or energy efficiency is received with much more enthusiasm. Overall, the effects of Eco Design (albeit those that only reduce environmental impacts without any other benefits) are seen by designers as part of good design principles; where good design principles are those that designers should abide by but may not fully do due to time and cost constraints at the product design stage.

B. Objectives

Whether and how environmental objectives (Eco Design objectives) are part of the design brief. Also regards environmental objectives that are conflicting with other design objectives.

Findings from the previous explorative stage (section 5.4): There is a clear lack of Eco Design objectives in design briefs. The facilities and organisation of the main actors' companies hinder the implementation of Eco design objectives. When implemented in a design brief, Eco Design objectives seem to cause difficulties. Clients may be wary of added costs, production facilities are not interested in any alternatives that do not require their capabilities (fear of losing jobs), and design teams may find expected results difficult to achieve alongside all other objectives. These findings lack validity due the nature of the funded projects followed (see section 5.1) and will be re-assessed in the next stage of research.

Eco Design objectives did not appear much during standard practice in the previous stage of research. In this stage of research, and with the exception of case **12-Purple** (where the investigation focused one single project), participants were asked about Eco Design objectives across all past and present design projects.

As developed earlier in section 5.1 and 6.1, the design activity differs from one case to another. There are firstly organisational differences, as to whether the case is a design consultancy or an in-house design team. Then, each design team works for a company (client or in-house) in a different industry (e.g.: point-of-sales for retail or furniture for offices). Even within the group of researched design consultancies (such as **14-Green** or **15-Sky**), the industries focused on is different (e.g.: medical, electronics, fast moving consumer goods, etc.).

As a result, the priority of design objectives are different, and the existence (or occurrence) of Eco Design objectives was found to be different too. **20-Aqua**, a design consultancy focusing on electronics prioritise design objectives relating to heat dissipation, miniaturisation and energy efficiency; which can all be linked to efficiency and Eco Design (respectively increasing product life, lowering energy use and reducing material use). On the other side, **13-Orange**, a company

manufacturing point-of-sales prioritise reducing time-to-market and cost; which are less likely linked to Eco Design objectives.

As developed in the literature review chapter, the type of product designed also calls for different types of Eco Design strategies. Electronics and other energy-using products would prioritise energy-efficiency; while point-of-sales would prioritise material efficiency and recyclability.

In the case of energy-using products, while reducing energy use benefits the end-user; the client of the design team usually is not the end-user or the stakeholder in charge of the product's energy costs. If the end-user was also the client, efficiency objectives would be aligned: the responsibilities and needs of the client are also those of the end-user. No case followed this pattern in this research. If the client is not an end-user: the client is interested in material efficiency (a cost the client is responsible for), but not interested in energy efficiency, unless motivated by legislation or competitive advantage. This appeared to be the case for all cases in this stage of research (the phenomenon was explained, for example, by **1701**, design director, **1501**, senior designer, **1401**, senior designer and **1901**, design engineer).

In the case of non-energy-using products, material efficiency was the main Eco Design strategy cases talked about (although they did not reference it as 'Eco Design').

In the case of Eco Design strategies that do not rely on efficiency, for example recyclability or alternative materials with lower environmental impacts, there is little incentive from any type of clients to act; unless there is a legislation (restricted substances) or commercial advantage (such as in **12-Purple** or **18-Blue**). Such objectives did appear in several cases, especially the design consultancies (**14-Green**, **15-Sky** and **17-Crimson**), but they were most of the time discarded along the design process before manufacture, apparently to reduce cost.

Also, sometimes, the mark-up on the price of a product is such that efficiency savings (such as materials saving) are negligible in terms of percentages of profit. This was something witnessed both in the previous stage of research and in cases **13-Orange** and **20-Aqua**. The saving of a few percent of the cost price of a

product does not seem to motivate clients in certain industries (maybe those with less fierce competition). For example, the clients of **20-Aqua** seem to put little importance in getting their home phones as material efficient as possible. The design team was not in charge of designing and placing internal components in the body of the phones, and was only given “rough dimensions” to work with. There was no priority put on the maximising the volume efficiency of the body and therefore of the materials involved in manufacturing them. However in **14-Green**, clients in the sector of fast moving consumer goods seem always interested to save a few grams. Other cases encountering similar issues (such as **14-Green**) explained that this however related more to ‘good design’ than Eco Design. Indeed, as developed in the previous theme, designing to maximise efficiency and therefore reduce costs is seen as good design, rather than Eco Design (which is interesting, since a main component to Eco Design is to not increase costs).

Finding: Clients are only interested in efficiency objectives within the boundaries of their system responsibilities (the costs that they are responsible for); unless they are motivated by legislation or competitive advantage. Eco Design objectives that do not relate to efficiency and lowering costs are very rarely part of design briefs, and when they are, they are often discarded along the way for cost reasons. Three variables were found to influence whether and how Eco Design objectives are implemented. These are:

1. Whether the client is also the end-user;
2. Whether the objective relates to efficiency (and lower financial costs);
3. Whether there is legislation or competitive advantage.

C. Adoption

This descriptive theme considers which (if any) Eco Design principles or approaches are either considered, or driving projects and the design process.

Findings from the previous explorative stage (section 5.4): While these cases show a spectrum of types of Eco Design adoption, none portray the academic textbook process Eco Design adoption and implementation (as seen in section 2.3 and 2.4); specifically where Eco Design drives the design process and influences the design choices based on environmental criteria. Overall, Eco Design adoption is arguable and limited to efficiency measures.

1401: We're not doing "arse" about it [implementing Eco Design], not very much at all at the moment. Maybe that's the type of clients we're working with.

Eco Design principles or approaches are seldom used in the design process. As explored in the previous theme, there is a clear lack of Eco Design objectives in design briefs. This lack of demand from clients translates into a lack of adoption of Eco Design approaches by design teams. Where Eco Design adoption is found, it is mostly in terms of efficiency (such as material efficiency, energy efficiency). However, design teams in some cases (such as **12-Purple**) talk about a certain change or improvement in directions towards more Eco Design adoption.

Design consultancies **14-Green**, **16-Navy**, **17-Crimson** and **20-Aqua** all expressed the lack of demand from their clients, and therefore the lack of adoption:

1401: To be honest, we don't really get that particular kind of project.

1701: It's virtually non-existent; to a lot of clients, it's a taboo subject.

15-Sky (one of the largest design consultancy) showed a clear lack of common adoption. Certain individual had initiatives in regards to Eco Design, but only related to personal interests. And while there is a slight adoption in terms of packaging design; it is driven by law requirements and efficiency. Overall, there is no company-wide adoption of any eco design principles or any initiatives to promote or disseminate Eco Design.

On the other hand, **18-Blue** showed great depth of Eco Design adoption. The company designs and manufactures in-house and uses a set of materials and processes specifically chosen for their environmental performance. A team of Eco Design experts within the company researches materials, processes while designers and engineers use this knowledge to develop products. However, there seems to be little interaction between designers/engineers and the Eco Design team. According to the interviewed design engineer (**1801**), the design process is impermeably separated from the Eco Design process. Designers and engineers are prescribed materials and processes to work with, and do not research or innovate on these aspects. While there are strong restrictions on the design process to remain within the Eco Design boundaries; for **1801**, there is no involvement in Eco Design by the designers and they end up dealing with the design process in the same “tick box” exercise manner described in other cases. This occurrence of Eco Design adoption is seen to be very unusual in two ways. First, the separation between the design process and the Eco Design process is not one encountered anywhere else in this research or seen in literature. Secondly, the pro-activeness of the Eco Design adoption in terms of final products (they are all assessed and rated highly by an independent organisation) is very rare too and unseen anywhere else in this research.

Finding: This stage of research also identified a clear lack of adoption of Eco Design principles. With the exception of 18-Blue, the only extent of Eco Design adoption relates to efficiency measures discussed in the previous theme. The lack of adoption is related, especially by design consultancies, to the lack of demand from clients.

D. Approaches

Collects the information on Eco Design approaches (including Eco-Tools) that had been given thought to. Also includes participants' views and opinions on the usefulness of those approaches.

Findings from the previous explorative stage (section 5.4): The funding provided to the cases allowed for the implementation of Eco Design approaches through the use of an Environmental Consultant (see section 5.1). However, this approach did not seem to fully succeed in implementing Eco Design in the cases. The disconnection of the consultant (and its Eco Design approach) from the design process hindered the projects and the implementation on the long-term of Eco Design within the design process of the cases. These findings however have little validity outside of the cases and the next stage of research should help in this aspect.

This stage of research unfortunately provided little evidence of the use of Eco Design approaches. The lack of such makes the coding and findings very similar to the previous theme. Most approaches to Eco Design are limited to efficiency measures; they do not include any ethical care for the environment, are not labelled as 'Eco' and are only motivated by financial savings.

12-Purple showed concern to reduce the environmental impact of the product in development. However, this does not illustrate the company's usual design process, but the design process for this specific project, that aimed to create a green alternative to their current offering. The approaches used here were that of auditing of the environmental impacts of a current base product against the environmental alternative and to research environmental materials.

14-Green (a large design consultancy) developed online forums and monthly meetings regarding Eco Design as a way to foster and develop knowledge on the discipline. The green champion took the initiative to create an assessment spreadsheet for design concept (based on Eco-indicator 99) and explained an external environmental consultant had once been used in a project and would be called for if needed. However enthusiastic about Eco Design, this case's approaches

to the process was limited to discussions about Eco Design, rather than actual work within the design process – again due to a lack of demand from clients.

Although self-branded as an innovation design consultancy, **15-Sky** showed no approaches to Eco Design whatsoever. The only hint of an approach to implement Eco design made by the different participants regarded the potential future hiring of an environmental consultant. **16-Navy**, a small design consultancy showed the same lack of any Eco Design capabilities or approaches.

18-Blue was the only case with an implemented and structured approach to Eco design. This approach is however very segmented from the design and engineering process. Neither designers nor engineers have contact with the Eco Design team, made of environmental experts with no design background. Eco Design experts assess environmental impacts of materials and processes and provide a strict protocol to follow to the designers and engineers. This clear separation between the Eco Design and Product Design process, as well as the prescriptive way to administrate an Eco Design approach to the design process is unique to this research, but also especially to the findings from the literature review. This may be due to the size of the case (a very large multinational company) and design-centred industry (furniture), and it would be interesting to investigate further outside the boundaries of this research, other companies of this type and their Eco Design implementation.

19-Pink, being a company producing lights, always has a drive to reduce heat loss and improve on power efficiency. However, these concerns relate to efficiency and are based on the financial bottom line rather than any environmental concern.

Finding: There is a clear lack of use of Eco Design approaches. Where they are used, they are limited to efficiency measures and are not implemented with the aim to reduce environmental impacts. While these approaches are likely to also reduce environmental impacts, there are no assessments to validate such claims. There seems to be an effort, especially by green champions and design consultancies, to gather and develop approaches such as consultants, and internal sources of knowledge (e.g.: library, forums, and databases).

E. Knowledge

Designers and teams' knowledge of Eco Design. How the knowledge is developed (e.g.: individually).

Findings from the previous explorative stage (section 5.4): There seems so far to be a link between the knowledge gathered and the personality or personal investment of the designer/individual. Across the cases, there was little belief in the value of learning about Eco Design and certainly no time/tasks set aside for this activity. This lack of knowledge within Eco Design is also seen by Lindahl (2005) as a hindering factor to the implementation of Eco Design.

This theme collects the information gathered during interviews assessing the level of Eco Design knowledge from the cases as well as how Eco Design and other new knowledge is developed within teams. Overall, there is little Eco Design knowledge in design teams, apart from the knowledge developed by eco-champions and brought by consultants. There is also a lack of knowledge development across design teams. Knowledge seems to be developed within each project, by individuals, in isolation of the overall activities of the design team. The knowledge gathered then usually stays with the designer having researched it (an issue that is developed in the next theme).

In all cases, participants explained the development of knowledge is mostly on an individual basis. **1501** (senior product designer) explains this trait best:

1501: It's on a project by project basis. Each designer will have a different range of skills (technical, front-end, conceptual), different scopes that depends on different interests. Some people do it naturally, they usually then email to a broader group if they think it'll be of use. It depends on the designer really. Not everybody is interested in new materials.

In terms of Eco Design, there is little knowledge development happening in design teams. In **14-Green**, three main people are the unofficially designated go-to designers in terms of Eco Design. They develop Eco Design knowledge within their own projects and in their own time. Their knowledge is mostly only available in

person, but a little part of it is published on internal forums, time allowing. A placement student was used to develop knowledge in the area, but the bulk of knowledge development remains with the individual.

Cases with in-house design teams (as opposed to design consultancies) all explained they received advice from suppliers of environmental alternatives or simply (claimed) more efficient products. **13-Orange** and **19-Pink**'s main source of knowledge relied on suppliers of materials proactively supplying information about the environmental credentials of their solutions. However, **13-Orange** also used a team-based knowledge development tool: an 'Eco-board' where each designer contributed by pinning articles, print-outs, of Eco Design alternatives, as well as new ideas relating to Eco Design. Every other month, the team meets and reviews the board to decide what to take on.

Occurrence of knowledge development methods in design consultancies seems to vary. **15-Sky** and **17-Crimson** showed no methods of Eco Design knowledge development past personal interest. **20-Aqua** use a collective material library for the team to collect samples of Eco Design alternatives, although the library is not extensively used, and overall, knowledge development relies only on the individual's curiosity from the employees. **14-Green** is the only design consultancy that provided extensive methods of knowledge development and transfer (explored in the next theme). These methods include the use of an online forum where staff can publish and read about new knowledge on all aspects of product design, and separate monthly meetings arranged by topics (including one on Eco Design). However, participants from this case (even the environmentally involved ones) explained these methods lacked content in Eco Design. They admitted that the monthly meetings on Eco Design were not well attended and that they themselves had little time to pursue the development of knowledge in this area, and to attend the meetings on Eco Design. **14-Green** showed surprising levels of knowledge in other areas electronics, medical, research skills, etc. However, all participants recognised the level of Eco Design knowledge and knowledge development is largely lacking behind. The green champion of this case also acknowledged his departure would mean the end of most Eco Design effort in the company. This feeling was also shared by other green champions in the previous

stage of research. Eco Design knowledge is, by the individualistic nature of knowledge development, locked in the few that are acquiring it.

Finding: While certain design consultancies can be very knowledgeable about their client's industry and in-house design teams receive knowledge from suppliers; there is little done in the field of Eco Design, and the knowledge acquired by a team is mostly that of its green champion. Eco Design knowledge is sparse and limited to individual interest, which seems to be a weakness to developing Eco Design capabilities.

F. Knowledge Transfer

How implementation is sustained, whether there are processes in place to drive further steps in Eco Design implementation.

Findings from the previous explorative stage (section 5.4, F. Sustaining Implementation): There is a lack of commitment to sustain Eco Design improvements, knowledge and generally implementation, ultimately failing to build on previous Eco Design efforts.

This theme relates closely to the previous one. However, here the research is interested in how Eco design knowledge (and other product design knowledge) is transferred and communicated to the design team, so to sustain Eco Design knowledge (and implementation) in time.

Most cases lack systems to transfer knowledge across the design team. While participants believe talking to each other is the most effective way to transfer knowledge, they also recognise this is in practice very difficult due to a lack of time, especially in large teams. Participants also seem reticent to knowledge transfer systems or methods and prefer the idea of meetings and discussions. As mentioned in the previous theme, **14-Green** has forums and monthly meetings where

members of the design teams can freely get informed on new development in specific fields. While this seemed a very promising approach to knowledge transfer, the participants explained priorities were getting in the way of attending these meetings, especially in the Eco Design; which is seen as less important than other fields.

Other design teams, such as in 15-Sky, 16-Navy, 17-Crimson, 19-Pink and 20-Aqua have very few systems in place to disseminate knowledge. **15-Sky** exemplifies the problems faced by these teams. Knowledge is not centralised for access by any member of the team, but participants seem happy to have to exchange verbally within the team:

1502: There is no central person or knowledge bank on environmental issues. It's about studio exchange, talking to each other. Historically, we're disorganised. But that is refreshing, it gives us cross-fertilisation and innovation. The fact we don't have a knowledge bank may be a good thing.

However, this ideal does not seem to be efficient in practice:

Interviewer: *So how do you find out about new materials and new technology?*

1502: *Not really well. Not really well at all.*

Interviewer: *Where would the information be?*

1502: *In a client's meeting, around the office. It's not organised, it's random, completely chaotic.*

The information is locked in within the individual:

Interviewer: *So what if tomorrow, someone had a client asking about sustainable materials, where would he/she look for the information in the company?*

1502: *They could talk to me, or couple other people and ask whether there is a point of reference, a previous project. We had a bank of brochures, but everything is on the internet now.*

Interviewer: *Where is your own information then?*

1502: *I have personal folders on my computer with projects and information.*

But due to the size of design teams, employees may not know who is knowledgeable in a certain area:

Interviewer: *How do you know who is best to do a project?*

1502: *In the past, we were smaller, we knew who everybody was. Now, we're too big to get a sense of all. Now, we sometimes send email an around the company.*

And in the end, the lack of systems makes it difficult to access knowledge:

Interviewer: *Is email your main mean to get to know this?*

1502: *Email and general discussions while making a cup of tea. We're the least structured design consultancy, and rely purely on word to mouth.*

Finding: There is a clear lack of knowledge transfer across all aspects of product design, and especially in Eco Design. There are very few systems in place to disseminate knowledge within design teams. This restricts Eco Design knowledge to the few individual with Eco Design interest (green champions), not to their company. Eco Design knowledge is therefore quite volatile and dependant on green champions remaining a member of the design team (personnel movement).

G. Communication and Collaboration

The (hindering or enabling) effects of Communication and Collaboration in the implementation of Eco Design. How Eco Design related information is communicated. How information is driven across teams and clients. How information is used in a collaborative way to improve the design process. How participants feel about communication and collaboration as being a potential issue to Eco design implementation.

Findings from the previous explorative stage (section 5.4): There is a lack of information received by design teams that hinders the understanding and implementation of the Eco Design strategies. This lack of communication and collaboration at design teams and product development teams levels that, while not confined to Eco Design, hinders the implementation of Eco Design.

Along with themes E. and F., this theme gathered the most data and insight about organisational settings influence Eco Design implementation. Most participants, especially designers, felt strongly about the lack of communication in design projects. As in the explorative stage, feelings of frustration were mostly expressed regarding this problem. In certain cases, this feeling of frustration was replaced by resignation. However, other (few) cases show communication and even collaboration systems in place. In terms of value, there was a certain divide between managerial and non-managerial positions on whether communication and collaboration was driver or barrier. The struggle expressed about lack of communication was also only felt by non-managerial positions and the reticence to communicate and collaborate internally was only seen by participants in managerial positions.

While most participants viewed communication and collaboration as drivers, some felt it was hindering the design process. In **19-Pink, 1901** (the design engineer, in a managerial position) felt the design team asked too many questions. He did not see the purpose of it and expressed a certain apathy towards their need to know more during the design process. Similarly, in **17-Crimson, 1701** (design director) was dismissive to the design team he manages:

1701: *We have a relatively young team, there are quite a few people sympathetic to the green approach [...].*

Interviewer: *Are there designers interested in the environment here? Are there any asking to do things differently?*

1701: *Yeah... [Blasé] They ask: “why are we printing in colour rather than black and white?”, “Why not double-sided?”, “Why not recycled paper?”, “Why not emailed instead of posted?”... We recycle... Most youngster are familiar with this...*

In **15-Sky**, there was a clear lack of communication and collaboration systems across the company. All participants expressed this view and the detrimental effects it had on the efficiency the design process as a whole. However, there was also an escalating feeling of resignation during interviews. While **1503** (design director) only expressed a need to “bolster organisational capabilities”, **1501** (senior product designer) expressed it “had always been this way” and **1502** (product designer) expressed plain frustration towards the lack of systems in place.

It is interesting to note that this scale of views matches the level of employees and that this convergence was seen across other cases, such as **13-Orange** and **16-Navy**.

Interestingly, in **12-Purple**, **1201** (the application engineer) and **1202** (the university researcher), both in managerial positions complained of the lack of communication from the other party. They felt the other was lagging behind in answering emails and presenting new findings, while at the same time expressing it was too early to move ahead. The lack of communication in this case reached a point of complete confusion, where it was impossible to understand the design process itself. The project stalled for weeks and months at a time, finally ending due to a lack of financial resources.

In **14-Green** (a large design consultancy), there seems to be the most systems in place for communication and collaboration. The company provides its employees with themed group meetings to exchange knowledge and ideas, internal online profiles and forums to ask questions and offer answers, as well as a seating plan which disseminate roles and levels of experience evenly across the company. While this seems to be providing ample means of communication and collaboration; Eco Design weighs quite low as a priority in these systems.

Interviewer: Do you also get to communicate with suppliers?

1401 (senior product designer): Yes. We talk to them to select the right materials and use their expertise.

Interviewer: And are you asking them about the sustainability of these solutions?

1401: Guaranteed no.

However, even in this somehow exemplary case of communication and collaboration, there is no documentation or key learnings gathered from previous projects and knowledge from experts in certain areas (such as the environmental champion interviewed - **1403**) are mostly locked in the person:

Interviewer: What would happen to the company's Eco Design expertise if you left?

1403: It would slow down, then it would stop. It depends who comes in. It would depend if someone stepped up to it. It's really about knowledge management and how a company keep and recycle information. That's why I'd like to manage our

knowledge. It is there, we just haven't captured it into bite size chunks. We acknowledge that it would be useful to do.

Finding: There is a general lack of communication and collaboration systems in place (which reflect findings from 'F. Knowledge Transfer'). This is seen by the vast majority as a barrier to Eco Design. Managerial personnel can be reticent to implement communication and collaboration activities. These problems are exacerbated when it comes to Eco Design. These findings are in line with the findings from the previous research stage.

H. Economic Climate

The effect of the current and past economic climate on the adoption and implementation of Eco Design.

Findings from the previous explorative stage (section 5.4): The current economic climate (recession of the late 2000's) is generally seen as hindering factor.

The occurrence of this theme that emerged during the explorative stage was corroborated during this research stage with added insights and complexities, summarised below in table 6.3. The influence of the economic climate on the implementation of Eco Design was not felt across all cases. And within the cases that were influenced, the economic climate was for certain a barrier and for others a driver to Eco Design. In cases such as **12-Purple**, the economic climate was highly influential and acted as a barrier to Eco Design implementation, ultimately stalling the project. However in **20-Aqua**, while the economic climate was also highly influential, it acted as a driver to increase efficiency. On the other side, for other cases, the economic climate was not of influence because of the prior lack of interest in Eco Design due to perceived cost inference (e.g.: **17-Crimson**); while in

18-Blue, the economic climate did little influence their already company-wide Eco Design implementation.


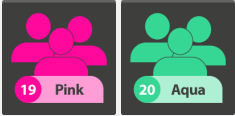
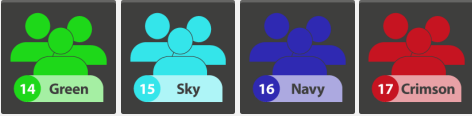
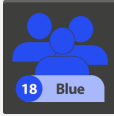
<p><i>Influenced</i></p> <p>Barrier to implementation (considered an added cost)</p> 	<p><i>Influenced</i></p> <p>Driver to implementation (Eco is considered an advantage)</p> 
<p><i>Not influenced</i></p> <p>No Eco Design implementation considered (considered an added cost)</p> 	<p><i>Not influenced</i></p> <p>Eco Design already implemented (considered an advantage)</p> 

Table 6.3 – The different cases categories regarding the influence and effect of the economic climate.

12-Purple was greatly influenced by the economic climate. As **1201** put it, as a result, the interest from his clients is gone. Although economic climate resulted in a reduced taskforce and in the project being delayed, the resilience and long-term planning of the company (due to long R&D timeframe) meant the project continued to work ahead: “*we need to look now so we can have the product for later*” (**1201**). This long-term planning despite a poor economic outlook was also quite unique amongst all cases. In **13-Orange**, the economic climate was seen to be a barrier to Eco Design because of its perceived added cost. The sales team, through dialogues with clients, did not mention Eco Design as it was seen by both parties as an extra they could not afford to focus on because of the economic climate: “*they [sales] don’t really use Eco Design as marketing except at the beginning contact, they just want to sell at the moment with the economic climate*” (**1303**).

In case **14-Green**, **16-Crimson** and **17-Navy**, Eco Design adoption was weak and the economic climate did not little to that. Participants expressed that current lack of adoption, demand and added cost to Eco Design was above any economic climate considerations.





Appearance	
The current economic climate is affecting the Eco Design implementation.	
<p>The current economic climate is seen as a barrier to Eco Design implementation.</p> <p>1201 <i>The interest from the clients is gone.</i></p> <p>1301 <i>The design and development team is really trying to make an effort, but purchasing is under so much pressure at the moment, that sustainability is second and first is price.</i></p> <div>  <p>14 Green</p> </div> <p>In 14-Green, the economic climate is not seen to be affecting the slow-paced Eco Design implementation, although lack of demand from clients for cost reasons still is.</p> <div>  <p>16 Navy</p> </div> <p>In 16-Navy, Eco Design is not looked at because clients feel it is irrelevant or even detrimental to cost criteria. This makes the economic climate irrelevant to Eco Design implementation.</p> <div>  <p>17 Crimson</p> </div> <p>In 17-Crimson, other design criteria such as cost and the fear to be wrong largely outweigh the interference the economic climate could make to Eco design implementation.</p>	<p>The current economic climate is seen as a driver to Eco Design implementation.</p> <p>2001 <i>Since last year, it has been very cost driven, lowering the amount of parts, using less plastics, less moulding; all to reduce costs.</i></p> <p>19-Pink's design of lights is purely driven by power consumption and by material efficiency to reduce initial and running costs. The economic climate only reinforces this drive.</p> <div>  <p>18 Blue</p> </div> <p>In 18-Blue, Eco Design is a core design and business principle, it is their unique selling point. While the economic climate had no effect on these principles; the company started producing a cheaper product line: partly because of the economic climate and partly because of change in market.</p>
The current economic climate is not affecting the Eco Design implementation.	
Nonappearance	

Table 6.4 – The influence of the economic climate on Eco Design implementation.

When considering efficiency as an element of Eco Design, certain cases and projects benefit from the economic climate in terms of Eco Design adoption. Indeed, participants from **19-Pink** and **20-Aqua** expressed they felt added pressure from an economic point of view to reduce energy use, mould parts, components and material. This in turn helped the environmental bottom line although it was never explicitly a design criterion.

In **18-Blue**, Eco Design is implemented across the whole company and works along the standard design process. Moreover, the company's main unique selling point advertised is that their products are environmentally friendly. Therefore, the economic climate did not influence their design process or design criteria. It did however partly influence the design of a cheaper range of products to accommodate a larger portion of the market.

Finding: Not all cases feel influenced by the economic climate in terms of Eco Design implementation. Some influenced cases found the economic climate to be a barrier to Eco Design implementation, while others saw it as a driver. In cases not influenced by the economic climate, some cases simply did not consider Eco Design any more than before (all design consultancies). Only one case that already implemented Eco Design found the economic climate not to influence implementation.

6.5 Methodological Reflection

This last section presents the methodological reflections that followed the undertaking of the research. It discusses the extent of the representativeness of the research, the internal and external validity (generalizability) of the findings and reflects on the collection of the data in regards to the methodology employed.

Methods

The use of an initial pilot study followed by two separate research stages greatly helped set up and strengthen the validity of the research. The pilot study enabled the research to understand the workings of the Product Design industry and to learn how to target the participants and communicate efficiently. Then, the use of two research stages proved useful in diversifying the enquiry, not only in terms of population, but in terms of methodology and data collection.

The first stage of research explored Eco Design implementation through the use of a comparative case study. This proved successful in exploring in depth the case settings, the views of the participants and their practices. This was only possible because of the participants' availability (30 interviews across four cases and 23 interviewees, an average of 5.75 interviewees per case and a ratio of 1.3 interviews per interviewee on average). During the second stage of research, the use of a cross-sectional case study design helped corroborate the initial findings. As explored in the methodology chapter, this approach was best suited to a lower availability of participants (21 interviews across nine cases and 20 interviewees, an average of only 2.22 interviewees per case and a ratio of 1.05 interviews per interviewee on average), and to address the need for a larger sample to help with generalisation. Overall, the research used a number of 13 cases (plus seven cases during the pilot study).

In both stages, data was collected through the use of semi-structured interviews. This allowed to gather the most information in relation to the limited availability of the participants. In regards to the limitations of this choice, it would have been useful to cross-reference the findings by collecting data via a secondary method in order to strengthen the internal validity of the findings for each case.

While this was considered from the outset of the research, the different cases were reluctant to have further involvement (such as document analysis or passive in-situ observation) because of time constraints and because of the secrecy generally involved in Product Design project with intellectual property.

The choice for a qualitative enquiry also had its limitations. From the outset, it was decided that the research would be primarily descriptive and focused on documenting the state and variety of Eco Design implementation (see section 3.1). This in turn limited the possibility for direct quantitative comparisons between cases on the appearance of the themes and findings. The structure of the presentation of findings through themes did not suit yes/no answers, but granular and multi-dimensional ones. The nature of the study was not that of a questionnaire but that of in-depth description of each theme degree and variety of occurrence.

Lastly, while the research tried to balance the use of 'green champion' participants with others; there may still be a certain bias present in this regard. Green champions and generally potential participants with an interest in Eco Design were easier to get in touch with, and understandably more inclined to want to talk about a subject they were interested in. Similarly, the invested nature of the researcher in Eco Design may have to some degree favoured findings expressing positive views of Eco Design. However, it is believed an equal interest in understanding opposite views should have reduced this bias to a minimum.

Representativeness

Section 1.5, The Product Design Industry:

"Therefore, in terms of cases selection for this research, it seems that diversity is key. On the one hand, large design consultancies and in-house design teams should provide insight on the bulk of the design work being undertaken in the UK. On the other hand, small businesses should help explore what drivers and barriers are faced by a large proportion of the design profession as well as identifying the different types of challenges small businesses face compared to larger ones." (p.16)

The research investigated Eco Design across 20 cases altogether, obtaining a sample through first convenient and then theoretical sampling activities (see section 3.2 and figure 3.2, p.72). This allowed to gather data from both design consultancies and in-house design teams, from very small local companies/teams to very large multinational ones. 57 participants (designers, engineers, production managers and managing directors) were interviewed, resulting in a varied set of data.

Overall, the participating design consultancies represented over 80% of the market shares of the British Product Design consultancy industry (see chapter 6, p.163). This level of investigation, in terms of sample size and diversity for the selected population, has not been found anywhere else in the literature; which in itself constitutes a unique contribution to knowledge (see section 8.4). However, it is important to restate that the Product Design industry is difficult to compartmentalise and define, and that therefore, it is also difficult to attest without doubt of the representativeness of any sample.

Data Collection

The data collection process has been discussed in depth during the methodology chapter (section 3.5) as well as during the research chapters themselves (sections 5.1 and 6.1). The initial pilot study (presented in chapter 4) provided insight on how to conduct the investigation and especially the collection of the data itself. At this stage, the interviewing questions were refined and the interviewer gained confidence in the process. Throughout the interviews, it was also helpful, for the interviewee and the interviewer to speak with the same design language. The Product Design background of the researcher indeed helped to engage quicker and at a deeper level with a common vocabulary. Deutz (2013) also noticed a similar experience during his research (but within an engineering background). The use of an audio recording device was also of great help, allowing the interviewer to focus on the conversation rather than transcription and note-taking. However it seems to have, in a few cases, constrained certain participants to express their view freely (e.g.: **1501**, see p.170).

It would have been desirable to undertake follow-up interviews to ask the participants about topics that they had not talked about at first, to ask them about their relationships with other members of the design process, and to dig deeper into their practices. Follow-up interviews did occur with a few participants that confirmed the promising potential for interesting findings using follow-up interviews. However, as developed in section 3.2 and along the research chapters, time is a precious resource in the Product Design industry and most participants were not available for a second interview. Also, given more time, it would have been interesting to collect further data on the design process of each case to see if there was any sort of relationship between, for example, the level of implementation of a design process and the level of implementation of an Eco Design process. While these ideas for further data collection were not considered due to the time constraints of the research program, they could be undertaken during future work.

Conclusions

This stage of research explored Eco Design implementation across nine cases to corroborate and fine-tune the findings from the previous stage of research. Two main types of cases appeared: in-house design teams and design consultancies. The cases varied greatly in terms of the design industry and size of the company. The participants across the cases also varied greatly in terms of their roles and experience.

There was hope this stage of research would allow to collect various findings on the types of Eco Design objectives, levels of Eco Design adoption and on the different Eco Design approaches and tools. However, the lack of Eco Design in the cases studied does not allow for such levels of analysis, but instead only demonstrates the lack of Eco Design across the British product design industry. As a result, this lack of granularity of findings in Eco Design implementation blurred the boundaries between the themes 'B. Objectives', 'C. Adoption' and 'D. Approaches'. Where theme B. should have provided findings on the types of Eco Design objectives, theme C. provided findings on the levels of adoption and theme D. provided findings on the different approaches and tools used in Eco Design implementation; they all mostly revealed their own lack of occurrence: the lack of Eco Design objectives, adoption and use of approaches and tools in the design process. All three themes however showed the distinct occurrence of a drive for efficiency. This drive for efficiency (to reduce material and energy use) was concerned with financial gains rather than environmental aspects and the vocabulary used by both clients and design teams only related to monetary terms. In themes 'E. Knowledge', 'F. Knowledge Transfer' and 'G. Communication and Collaboration', the lack of Eco Design implementation often resulted in widening the questioning outside of Eco Design activities to the whole design process.

Overall, the findings provided a more general picture of the Eco Design implementation in the British product design industry, in most respect in line with the findings from the previous stage of research. While discussion of these findings and comparisons of findings between the two stages of research are developed in the following chapter; the findings from this stage of research are reproduced below:

A. Views: While the age of the respondents was not recorded during the research, there seems to be a generational factor in how Eco design is viewed. Younger generations (and more junior job roles) empathised much more with environmental issues, with a couple of exceptions. Participants generally wish more was done in Eco Design but feel powerless due to external factors.

A¹. Ethics: ‘Green champions’ believe more should be done and personally feel for the environment. They are personally involved, not only at work, but during their daily lives. They are evangelists within their design team and company, and take on projects on personal time to improve the Eco Design implementation of their company. This is balanced by a vast majority of designers apathetic to the issue, either voicing their lack of interest or their lack of lee-way to choose to approach the issue (see next theme, ‘A2. Responsibility’).

A². Responsibility: Most designers feel the responsibility to engage on Eco Design ultimately lies with their clients. Certain participants feel that because this is the case, clients have to ask them to work on Eco design for them to consider the issue. Other participants with higher feeling of responsibility vis-à-vis of the environmental impacts of their designs showed greater involvement in pursuing Eco Design both personally and by trying to involve colleagues and clients.

A³. Time and Trust: There is a clear lack of time to research Eco Design amongst design teams and a lack of trust in Eco Design alternatives. The industry is wary of making marketing claims on the environmental benefits of Eco Designed alternatives without tangible undeniable proofs and the lack of standardised environmental assessment.

A⁴. “Good Design”: Vocabulary is important when discussing Eco Design. According to Design Teams’ experiences, terms directly relating to the environment inspire fear and added cost to clients, and to designers to a lesser degree. But talking about the effect of Eco Design, such as light-weighting or energy efficiency is received with much more enthusiasm. Overall, the effects of Eco Design (albeit those that only reduce environmental impacts without any other benefits) are seen by designers as part of good design principles; where good design principles are those that designers should abide by but may not fully do due to time and cost constraints at the product design stage.

B. Objectives: Clients are only interested in efficiency objectives within the boundaries of their system responsibilities (the costs that they are responsible for); unless they are motivated by legislation or competitive advantage. Eco Design objectives that do not relate to efficiency and lowering costs are very rarely part of design briefs, and when they are, they are often discarded along the way for cost reasons. Three variables were found to influence whether and how Eco Design objectives are implemented. These are:

1. Whether the client is also the end-user;
2. Whether the objective relates to efficiency (and lower financial costs);

3. Whether there is legislation or competitive advantage.

C. Adoption: This stage of research also identified a clear lack of adoption of Eco Design principles. With the exception of 18-Blue, the only extend of Eco Design adoption relates to efficiency measures discussed in the previous theme. The lack of adoption is related, especially by design consultancies, to the lack of demand from clients.

D. Approaches: There is a clear lack of use of Eco Design approaches. Where they are used, they are limited to efficiency measures and are not implemented with the aim to reduce environmental impacts. While these approaches are likely to also reduce environmental impacts, there are no assessments to validate such claims. There seems to be an effort, especially by green champions and design consultancies, to gather and develop approaches such as consultants, and internal sources of knowledge (e.g.: library, forums, and databases).

E. Knowledge: While certain design consultancies can be very knowledgeable in their client's industry and in-house design teams receive knowledge from suppliers; there is little done in the field of Eco Design, and the knowledge acquired by a team is mostly that of its green champion. Eco Design knowledge is sparse and limited to individual interest, which seems to be a weakness to developing Eco Design capabilities.

F. Knowledge Transfer: There is a clear lack of knowledge transfer across all aspects of product design knowledge, and especially in Eco Design. There are very few systems in place to disseminate knowledge within design teams. This restricts Eco Design knowledge to the few individual with Eco Design interest (green champions), not to their company. Eco Design knowledge is therefore quite volatile and dependant on green champions remaining a member of the design team (personnel movement).

G. Communication and Collaboration: There is a general lack of communication and collaboration systems in place (which reflect findings from 'F. Knowledge Transfer'). This is seen by the vast majority as a barrier to Eco Design. Managerial personnel can be reticent to implement communication and collaboration activities. These problems are exacerbated when it comes to Eco Design. These findings are in line with the findings from the previous research stage.

H. Economic Climate: Not all cases feel influenced by the economic climate in terms of Eco Design implementation. Some influenced cases found the economic climate to be a barrier to Eco Design implementation, while others saw it as a driver. In cases not influenced by the economic climate, some cases simply did not consider Eco Design any more than before (all design consultancies). Only one case that already implemented Eco Design found the economic climate not to influence implementation.

Chapter 7 - Discussion of Findings

This chapter groups and discusses the findings from the main stages of this research: the explorative stage (chapter 5) and the corroborative stage (chapter 6). The findings are discussed per theme (section 7.1 to 7.4) with the last section (7.5) presenting the overarching findings to this research. For each section, factors linked to Eco Design implementation are summarised.

Introduction

The aim of this chapter is to consolidate the findings from the different stages of the research to provide more room for validation and generalisation. The findings from each of the research stages are recapitulated and discussed per theme and as overall findings. Because of its similarities in terms of research aim, Dewberry's research (1996) on Eco Design practices (introduced in chapter 2) is cited throughout this chapter; thereby providing a historical perspective and point of comparison. Lastly, this chapter also introduces and summarises the factors hindering or driving Eco Design implementation for each theme.

7.1 Views

Findings from the Explorative Stage

There is a general feeling that Eco Design is an **important** part of the product design process, but that it is **in practice difficult** to incorporate. There are feelings of **frustration and cynicism** towards the (lack of) implementation of Eco design, but also some **indifference** by some participants.

Findings from the Corroborative Stage

There seems to be a **generational factor** in how Eco design is viewed. Younger generations **empathised** much more with environmental issues, with a couple of exceptions. Participants generally **wish more** was done in Eco Design but feel **powerless** due to external factors.

The findings from the Explorative Stage were largely substantiated during the Corroborative Stage. Similar feelings of frustration, cynicism and indifference were expressed for the same reasons and there was also amongst the participants of this latter stage the feeling that Eco Design was an important part of the Design process but difficult to implement due to external factors. However, new findings also arose from the Corroborative Stage of research. Upon further analysis of the data, a generational factor for empathy on environmental issues was also found in cases **08-Gold (0801, graduate product designer)**; but was contradicted by the indifferent views of her colleague (**0802, product design intern**), the positive views of **0901 (company director)** and **0902 (senior account manager)**, and the indifferent views of **1102 (junior product design)**. Therefore, while a majority number of ‘green champions’ were amongst the younger generations; indifferent and negative views towards Eco Design were found across all generations. Participants of both stages of the research expressed most clients were not interested in Eco Design because they could not see the commercial benefits (see theme A. Views in sections 5.4 and 6.4). This especially appeared amongst design consultancies (**14-Green, 15-Sky, 16-Navy, and 17-Crimson**); which was also seen by Dewberry (1996).

This view regarding the inherent need for commercial benefit in Eco Design is discussed further in section 7.5, ‘Lack of Demand’.

Drivers

Eco Design is seen as an important part of the Product Design Process.

Barriers

Eco Design is not regarded as realistic in business terms due to a perceived lack of commercial benefits.

Ethics

Findings from the Explorative Stage

Some participants take Eco Design and environmental issues particularly to **heart**. They truly **feel** for the environment, and strongly **believe** in the need to do more as a society. These participants also show **personal involvement**, way beyond the requirements of their roles.

Findings from the Corroborative Stage

'Green champions' believe more should be done and personally feel for the environment. They are **personally involved**, not only at work, but during their daily lives. They are **evangelists** within their design team and company, and take on projects on personal time to improve the Eco Design implementation of their company. This is balanced by a vast **majority of designers apathetic** to the issue.

The findings from this theme were consistent across the stages of the research. The latter stage confirmed previous findings and supported the productive and positive presence that 'green champions' can have to the implementation of Eco Design within the design process and design teams. The corroborative stage also confirmed that design teams can contain apathetic designers with little concern for the environment and Eco Design. Also, while the gathering of Eco Design information by 'green champions' is often regarded as commendable by senior management; the learning is in most cases self-driven and there is a certain isolation and loneliness to the green champions' activities.

The same notions of empathy towards the environment as well as the term 'environmental champion' also appears within Dewberry's research (1996). Dewberry also similarly found that the Eco Design efforts are in some cases only driven by the green/environmental champion of the design team. The convergence of these findings help their generalisation across both time and the product design industry.

Drivers

Personal investment and interest by a design team member (green champion) increases the Eco Design awareness and knowledge of the team and can positively influence the design process.

Barriers

Equally, a design team's lack of interest or concern for the environment and Eco Design limits the implementation of Eco Design to external pressures from the brief (if any).

Responsibility

Findings from the Explorative Stage	Findings from the Corroborative Stage
Certain participants feel responsible for the production (direct or indirect) of their designs. Similarly to theme 'A1. Ethics', these participants feel the need to push for the implementation Eco design. Other participants dismiss Eco Design and responsibility in contributing to environmental impacts. This attitude seems to be a barrier to Eco Design adoption.	Most designers feel the responsibility to engage on Eco Design ultimately lies with their clients . Certain participants feel that because this is the case, clients have to ask them to work on Eco design for them to consider the issue. Other participants with higher feeling of responsibility vis-à-vis of the environmental impacts of their designs showed greater involvement in pursuing Eco Design both personally and by trying to involve colleagues and clients .

Both stages of research showed similar findings. In the first explorative stage however, the feeling of responsibility was felt at more junior positions than during the corroborative stage; which may explain why green champions of this latter stage were able to have a greater influence on the implementation of Eco Design. Only a minority of participants felt personally responsible for (the lack of) Eco Design in their design process; and by taking the issue at heart, often managed to at least engage their teams in the issue (e.g.: **0801, 1301, 1403**). This is consistent with findings from the literature, such as Deutz et al.: *"The knowledge and personal concerns of individual designers are significant, albeit necessary rather than sufficient for eco-design to be implemented"* (2013, p.127). However, the majority of the participants felt that Eco Design implementation was out of their control. They explained that they are restricted by working for a client or market that does not ask for environmental issues to be addressed. These views are also clearly expressed in Dewberry's research (1996), especially in regards to the lack of power felt by her participants: *"they felt that they were in no position to take responsibility for the incorporation of environmental criteria and imposing this philosophy on their clients."* (p.170) and *"Many designers acknowledged that the majority of the design decisions were made by management before the brief even reached the design team"* (p.201). This last aspect appeared in several cases (such as **08-Gold** and **11-Lime**). The participants felt Eco Design responsibility was too low down the chain of management and therefore unable to make changes to the briefs.

At the other end, a minority of participants felt Eco Design had nothing to do with them or that it was not one of their responsibilities, and explained it was up to the clients to ask about Eco Design.

Drivers

Members of design teams with personal feeling of responsibility and personal concerns often try to encourage their team to implement Eco Design.

Barriers

A general lack of 'felt' responsibility by the design team often translates in a lack of dialogue on Eco Design issues and apathy towards the issue.

Time and Trust

Findings from the Explorative Stage

The **fast-paced** nature of the design process hinders Eco Design implementation, which requires time and resources that are not available. Designers have little to **no time** allocated to research on new materials and other innovations. This includes time to consider Eco Design alternative – let alone time to **test or assess** alternatives.

Findings from the Corroborative Stage

There is a clear **lack of time** to research Eco Design amongst design teams and a **lack of trust** in Eco Design alternatives. The industry is wary of making **marketing claims** on the environmental benefits of Eco Designed alternatives **without tangible undeniable proofs** and the **lack of standardised environmental assessment**.

Both stages provided similar and corroborating findings. The product design industry has little time and expertise to research, test and assess Eco Design alternatives and there is a lack of recognised assessment standards to use and choose from. Dewberry's research (1996) also found the same confusion regarding what to believe and trust when it comes to environmental claims. The findings from this research confirm that the confusion comes from too much information and a lack of adopted standards.

According to a majority of interviewees, Eco Design is seen as a discipline with conflicting opinions. There is confusion as to why different environmental alternatives and strategies seem to contradict each other. This results in a general lack of confidence and sometimes trust in the discipline, in particular regarding the claims made for environmental alternatives and implementation methods such as

eco-tools and software. Consultancies, such as **15-Sky** and **17-Crimson**, are particularly worried environmental claims could turn out to be false as they have seen it happen to other companies in the past, and that this could consequently damage their reputation (a finding similar to that from Dewberry's research 1996). In some cases, there is also a belief or concern that environmental alternatives will hinder the products' functions, properties or another part of the design.

20 years after Dewberry's research (1996), Eco Design remains a fringe, innovative field within product design. Investigation in this domain requires a considerable amount of resources (such as time) to investigate, that design teams simply do not have.

<p>Drivers</p> <p>A trust in, and dedicated time to research, environmental alternatives enables the implementation of Eco Design.</p>	<p>Barriers</p> <p>The combined lack of adopted assessment standards (and assessed environmental alternatives) and a lack of time within the design process hinders the adoption of mistrusted environmental alternatives and adoption of an Eco Design process.</p>
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Good Design

<p>Findings from the Explorative Stage</p> <p>N.A. (This particular theme only emerged during the corroborative stage of research).</p>	<p>Findings from the Corroborative Stage</p> <p>Vocabulary is important when discussing Eco Design. According to Design Teams' experiences, terms directly relating to the environment inspire fear and added cost to clients, and to designers to a lesser degree. But talking about the effect of Eco Design, such as light-weighting or energy efficiency is received with much more enthusiasm. Overall, the effects of Eco Design (albeit those that only reduce environmental impacts without any other benefits) are seen by designers as part of good design principles; where good design principles are those that designers should abide by but may not fully pursue due to time and cost constraints at the product design stage.</p>
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Participants expressed the view that the practice and the use of Eco Design principles and methods were similar to those of ‘good design’ practice and methods. This term, shared by interviewees, defined the best practice in design and what design should be about. While this theme only first emerged during the data analysis of the corroborative stage; further retrospective analysis of the explorative stage did find mention relating to ‘good design’ that reinforced the nature and existence of the theme overall.

While there is no actual mention of the term ‘good design’ in Dewberry’s work, there are discussions about the idea that Eco Design is/should be an integral part of product design. *“Some felt that the environment was just another criteria to be considered alongside cost, quality, aesthetics, performance, etc”* (Dewberry, 1996, p.201). This view seems to have become more popular nowadays.

Drivers

The use of vocabulary is important when approaching Eco Design. Discussing efficiency, lower energy and materials cost, as well as ‘good design’ without mentioning Eco Design may help, counter-intuitively, the implementation of Eco Design.

With increased awareness of our environmental impacts, there may be a trend where designers increasingly feel Eco Design should be/is part of ‘good design’ principles.

Implications

This research has shown that a practitioner’s personal interest can go a long way towards Eco Design adoption. But their influence is most often limited to the design team and to the specific projects they are working on. It does not extend to the company’s overall environmental policy, and is most importantly only limited to *suggest* Eco Design strategies to clients and management. While the literature has put forward the positive influence of these ‘environmental champions’; caution should be taken to not put too much faith on this driving force as their control over the design brief and design outcomes is quite limited. Additionally, this research has shown the presence of designers with varying feelings of responsibility towards

environmental impacts. While this can positively impact Eco Design implementation, it has been shown to have a limited influence and overall little repercussions in terms of design outcomes. This driver should therefore not be relied upon either. Practitioners' views in terms of ethics and responsibility in design should not be relied upon as a driving force because it has been shown in this research to bring little practical outcome in the design process. This is because there is no requirement for companies to follow through those views and that companies have no motives to follow altruistic drivers to Eco Design implementation. Stricter Eco Design legislation needs to be put in place to push companies to act on those views and consequently adopt and implement Eco Design.

Over the last 20 years, academics have focused their efforts towards the creation of tools and information (inspirational examples of Eco Design, methods of implementation, environmental material and product claims, etc.). However, this content has been developed in isolation from one another, rather than building up to a cohesive collection of information. This has resulted in a duplication of efforts, making it difficult for practitioners to wade through Eco Design information (which brought issues of lack of time). This has also generated confusion, especially in regards to divergent opinions on how Eco Design should be implemented and conflicting environmental claims. As a result, practitioners also find it difficult to assess the reliability of Eco Design information (which brings issues of lack of trust). Practitioners need access to a trust-worthy and appropriately packaged source of information and training on Eco Design. This information needs to be approved and should be the result of a collaborative approach, bringing academics and industry knowledge together. This would speed up their access to Eco Design knowledge, and ultimately facilitate adoption and implication of Eco Design.

7.2 Objectives, Adoption and Approaches

Across all cases, there were no projects driven by Eco Design principles and there were very few projects where the implementation of those principles was considered. Moreover, the cases that consciously looked at Eco Design were primarily driven by hopes that there would be a cost benefit, rather than environmental concerns.

As explained in the previous chapter, this resulted in a lack of granularity of findings in Eco Design implementation that generated fuzzy boundaries between the themes 'B. Objectives', 'C. Adoption' and 'D. Approaches'. Where theme B. should have provided findings on the types of Eco Design objectives, theme C. provided findings on the levels of adoption and theme D. provided findings on the different approaches and tools used in Eco Design implementation; they all mostly revealed their own lack of occurrence: the lack of Eco Design objectives, adoption and use of approaches and tools in the design process. All three themes however showed the distinct occurrence of a drive for efficiency. This drive for efficiency (to reduce material and energy use) was concerned with financial gains rather than environmental aspects and the vocabulary used by both clients and design teams only related to monetary terms.

Objectives

Findings from the Explorative Stage

There is a clear **lack** of Eco Design objectives in design briefs. The facilities and organisation of the main actors' companies hinder the implementation of Eco design objectives. When implemented in a design brief, Eco Design objectives seem to cause difficulties. Clients may be **wary of added costs**, production facilities are not interested in any alternatives that do not require their capabilities (fear of losing jobs), and design teams may find expected results **difficult to achieve** alongside all other objectives. These findings **lack validity** due the nature of the funded projects followed (see section 5.1) and will be re-assessed in the next stage of research.

Findings from the Corroborative Stage

Clients are only interested in **efficiency objectives** within the **boundaries** of their system responsibilities (the costs that they are responsible for); unless they are motivated by legislation or competitive advantage. Eco Design objectives that do not relate to efficiency and lowering costs are very rarely part of design briefs, and when they are, they are often discarded along the way for cost reasons. Three **variables** were found to influence whether and how Eco Design objectives are implemented. These are:

1. Whether the client is also the end-user;
2. Whether the objective relates to efficiency (and lower financial costs);
3. Whether there is legislation or competitive advantage.

The corroborative stage of this research helped validate initial findings regarding the lack of environmental objectives in design briefs. It also helps corroborate the issues and barriers participants experienced when trying to integrate environmental objectives in the brief.

Environmental objectives found in project briefs are typically associated with reducing weight or energy use, increasing the recyclable contents of materials, looking at more environmentally friendly materials, etc. In all cases however, the cost constraints are placed higher in priority than the environmental ones. Moreover, environmental objectives are pursued in the knowledge that they have the potential to lower costs or at least to keep them the same.

On another level, there is a clear lack of cohesion between projects' environmental objectives and the overall company environmental objectives (a finding that is also present in Dewberry's research (1996)). The interviewees directly involved in product development are usually not aware of the environmental objectives set by the companies selling the products nor do they appear in the briefs. If the project briefs do include environmental objectives, they are again usually set without the knowledge of the environmental management teams. In effect, it seems companies' overall environmental strategies do not reach

project briefs and design teams. Consultancies were most expressing this lack of involvement in regards to Eco Design strategy implementation.

Environmental objectives also differ greatly according to which industry the product development applies to. During this research, certain categories have emerged in this regard:

Innovators: in the case **12-Purple**, the company needs to bring innovation to its clients in order to stay ahead of its competitors and having an ‘environmental edge’ was seen to be a potential way to do this.

Energy-using products: **19-Pink** develops lights and advertise performance through lower energy consumption. **10-Teal** manufactures train seats where lowering weight for fuel-efficiency during the lifetime of the product is the principal objective. This drive for efficiency is intended to contribute to the bottom line and to adhere to regulations. It also happens to be consistent with the environmental bottom line (by reducing the embodied energy and carbon footprint of their products). This is simply the case for products where the larger proportion of the environmental impact comes from the energy consumption during the use phase.

Customer facing where branding is sensitive: **13-Orange** designs consumer-facing retail units for big brands. Here, the push mostly comes from a branding perspective. **13-Orange**’s clients want to be seen to be green and will engage in one-off products to show their environmental credentials, but only if the costs do not outweigh the marketing benefits. **19-Pink**’s retail clients will do the same, implementing in flagship stores the most environmental lighting options. **11-Lime** does not want their design to ‘look environmentally bad’ in front of the customer, a position that motivated them to work on more efficient packaging.

Eco Design as a unique selling point: **18-Blue** shows that companies can implement Eco Design and use it as a selling point. While the mechanisms for such a business model are not fully understood here, certain aspects may be contributing factors. The company is very large and global, producing high volumes of products that are in the high price range within their market, and they are experts in lean manufacturing and efficiency (in terms of materials, energy and logistics). **08-Gold** also markets their green credentials to sell their products.

However, their small size, lack of knowledge and experience in Eco Design; as well as a much smaller economy of scales puts them half-way between this category and the next.

The others: Small companies seem to have few incentives and little leeway to manoeuvre the implementation of Eco Design in their product development processes, and ultimately, their clients are not interested.

<p>Drivers</p> <p>The presence of Eco Design objectives empowers the design team to allocate time and resources to Eco design, and to grow their knowledge in the area.</p>	<p>Barriers</p> <p>The lack of Eco Design objectives in the brief is the greatest single barrier to Eco Design implementation. (This is discussed further in section 7.5).</p>
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Adoption

<p>Findings from the Explorative Stage</p> <p>While these cases show a spectrum of types of Eco Design adoption, none portray the academic textbook process Eco Design adoption and implementation (as seen in section 2.3 and 2.4); specifically where Eco Design drives the design process and influences the design choices based on environmental criteria. Overall, Eco Design adoption is arguable and limited to efficiency measures.</p>	<p>Findings from the Corroborative Stage</p> <p>This stage of research also identified a clear lack of adoption of Eco Design principles. With the exception of one case, the only example of Eco Design adoption relates to efficiency measures discussed in the previous theme. The lack of adoption is related, especially by design consultancies, to the lack of demand from clients.</p>
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Both stages identified a drive for efficiency, but a lack of Eco Design adoption. As for investments in Eco Design, both in-house teams and consultancies expressed their uncertainty regarding what to invest in and doubts about the potential for return on investment. Senior level staff thought that Eco Design was not asked for enough by clients to be worthy of investment. Few knew what they would do next if they had to develop this part of their offer and would have to look into it further at that time if the need arose. **14-Green** was the design consultancy with the most Eco Design involvement. This was limited to an organised way to

share resources between the personally involved ‘green champions’, but it bore no sign of actual Eco Design adoption within projects. **18-Blue** was the company with the most Eco design involvement, but this was limited to a team of environmental experts prescribing materials and processes to the design team and there was no actual Eco Design adoption within the design process.

Drivers & Barriers

The themes ‘C. Adoption’ and ‘D. Approaches’ are purely descriptive of whether adoption of Eco Design occurs, and of whether (and which) approaches are used. Drivers and barriers do not really apply to these themes. At most, it is simply the occurrence itself of the theme that constitutes its driver, and the lack of, its barrier (e.g.: the occurrence of adoption is a driver of Eco Design adoption, the lack of is a barrier). The subsequent themes discuss the findings on the workings of Eco Design implementation, and consequently present their related drivers and barriers.

Approaches

Findings from the Explorative Stage

The funding provided to the cases allowed for the implementation of Eco Design approaches through the use of an **Environmental Consultant** (see section 5.1). However, this approach did not seem to fully succeed in implementing Eco Design in the cases. The disconnection of the consultant (and its Eco Design approach) from the design process hindered the projects and the implementation over the long-term of Eco Design within the design process of the cases. These findings however have **little validity** outside of the cases and the next stage of research should help in this aspect.

Findings from the Corroborative Stage

There is a clear **lack of use** of Eco Design approaches. Where they are used, they are limited to **efficiency** measures and are not implemented with the aim to reduce environmental impacts. While these approaches are likely to also reduce environmental impacts, there are no assessments to validate such claims. There seems to be an effort, especially by green champions and design consultancies, to gather and develop approaches such as consultants, and internal sources of knowledge (e.g.: library, forums, and databases).

The use of eco-tools by industry has been identified during the literature review as very limited (see section 2.5), and the research concurred that there was a total absence of eco-design tools being used across all cases. Only one case, a large design consultancy (**14-Green**), developed a spreadsheet linking environmental impact data to a bill of materials. Within this company, only one

person was fully aware and able to use the tool and it had yet to be used in projects. At most and only in a few cases, Eco Design approaches related to designers following principles of Eco Design without any systematic methods of environmental impact measurement and instead the use of rules of thumb and peer advice.

Dewberry's research (1996) found Life Cycle Analysis tools used in two cases. However, participants in her research felt this approach was not seen so effective in practice, and that a less rigorous 'ball-park' approach would be more beneficial. Dewberry's research also found that there was a good argument for integrating environmental expertise within the design team. The explorative stage of the current research shows otherwise that the integration of an environmental consultant was not successful, and generally not positively received. However the integration of environmental expertise in the current research differed, as the consultant was external to the companies where it was in-house in Dewberry's case. This concurs with the findings from the corroborative stage of research where internal green champions were seen to be drivers in the use of Eco Design approaches.

Drivers & Barriers

The themes 'C. Adoption' and 'D. Approaches' are purely descriptive of whether adoption of Eco Design occurs, and of whether (and which) approaches are used. Drivers and barriers do not really apply to these themes. At most, it is simply the occurrence itself of the theme that constitutes its driver, and the lack of, its barrier (e.g.: the occurrence of adoption is a driver of Eco Design adoption, the lack of is a barrier). The subsequent themes discuss the findings on the workings of Eco Design implementation, and consequently present their related drivers and barriers.

Implications

The findings from this section provide a sad picture of the current lack of Eco Design adoption. There is very little happening in British Product Design in terms of Eco Design implementation. The initial lack of Eco Design objectives in design briefs results in a lack of adoption and use of Eco Design approaches.

Eco Design deals with products' lifecycle impacts. While these impacts are mostly set at the design stage (Tischner, 2000), the generation of impacts occurs mainly at other stages of the life cycle of the product (e.g.: extraction or disposal). The responsibility for these impacts then mainly fall under the actors of these stages (e.g.: suppliers, consumers, waste handlers). At the moment and under current legislation, the company commissioning the product has very little responsibility over the products lifecycle impacts. While the company's responsibility is sometimes extended to include other life cycle stages, this is only the case for a specific few product categories (e.g.: vehicles) or for very specific aspect of a product (e.g.: restrictions on the use of hazardous substances).

As a result and as seen in this research, companies take little responsibility for the environmental impacts of their products and this translates in a lack of Eco Design implementation.

7.3 Organisational Implementation

As in the previous section with themes ‘B. Objectives’, ‘C. Adoption’ and ‘D. Approaches’, the lack of Eco Design implementation often resulted in widening the questioning outside of Eco Design activities to the whole design process for the themes ‘E. Knowledge’, ‘F. Knowledge Transfer’ and ‘G. Communication and Collaboration’.

Knowledge

Findings from the Explorative Stage

There seems so far to be a link between the **knowledge** gathered and the personality or **personal investment** of the designer/individual. Across the cases, there was little belief in the value of learning about Eco Design and certainly no time/tasks set aside for this activity. This **lack of knowledge** within Eco Design is also seen by Lindahl (2005) as a hindering factor to the implementation of Eco Design.

Findings from the Corroborative Stage

While certain design consultancies can be very knowledgeable about their client’s industry and in-house design teams receive knowledge from suppliers; there is **little done** in the field of Eco Design, and the knowledge acquired by a team is mostly that of its **green champion**. Eco Design **knowledge is sparse** and limited to individual interest, which seems to be a weakness to developing Eco Design capabilities.

A key element within this research concerns the individualistic nature of Eco Design knowledge. Isolated employees develop this knowledge mostly through personal interest and in turn try to drive Eco Design implementation but believe it needs to be led by senior staff to be successful. Whilst those interviewees most interested in Eco Design spend some of their time looking at the discipline, none declared that they had received professional training on the subject. The gathering of information and learning is in most cases self-driven. Because Eco Design is not encountered in many projects and learning about it does not appear to be critical; knowledge development is weak. The interviewees’ time is not accounted towards expanding Eco Design knowledge in any of the cases. Most feel they are not given the time, and do not bear the responsibility to gather knowledge on Eco Design.

As Dewberry (1996) also found in her research, the way Eco Design information is produced and received by designers is a key requirement to improve Eco Design implementation. This research also found that Eco Design information needs to be scientifically demonstrated, obtain general consensus to avoid misinformation and ensure that it is easily understood by practitioners. This aspect is as important as the development of the information itself.

Participants across both stages of the current research expressed their lack of trust towards Eco Design knowledge itself. Due to contradicting and confusing information, designers in this research also explained they found it hard to access knowledge. This also added to the time needed to ‘wade through’ information to gather the right knowledge, further impacting on the lack of time for research expressed across the cases. These elements clearly demonstrated the relationship between lack of time, lack of trust and lack of knowledge development. Interestingly, these findings are similar to those collected by Dewberry (1996) 20 years ago. Advances in the field of Eco Design and advances in the digital and information age seems to have had little benefit to developing and/or accessing useful knowledge.

Drivers

Methods to grow Eco Design knowledge base will allow the Design Team to implement Eco Design across future projects.

Barriers

Lack of Knowledge Development in Eco Design does not allow designers to learn, research on Eco Design and Environmental Alternatives. A lack of clear and concise Eco Design information representing scientific consensus impedes designers’ abilities to develop knowledge in the area.

Knowledge Transfer

Findings from the Explorative Stage

There is a **lack of commitment** to sustain Eco Design improvements, knowledge and generally implementation, ultimately failing to build on previous Eco Design efforts.

Findings from the Corroborative Stage

There is a clear **lack of knowledge transfer** across all aspects of product design, and especially in Eco Design. There are very **few systems** in place to disseminate knowledge within design teams. This restricts Eco Design knowledge to the few individual with Eco Design interest (green champions), not to their company. Eco Design knowledge is therefore quite **volatile** and dependant on green champions remaining a member of the design team (personnel movement).

In the majority of cases and throughout the research stages, there is no process to drive Eco Design across the product development team. This is usually explained by a lack of time and resource. In **14-Green**, the use of knowledge transfer methods (forums, newsletters, employee profiles with skill-sets, regular topical meetings) allows for the dissemination of knowledge across the consultancy. However, even in this example, Eco Design is one of the least prioritised topics.

In most cases, sustaining Eco Design implementation seems as difficult as the implementation itself. Interviewees encountering the problem explain that implementing an environmental alternative on one project provides little benefit for the following one. The knowledge and experience gained on the former is consequently lost as there are no methods to store or build this knowledge. This provides Eco Design with one of its biggest barriers that is the management and therefore the development of this knowledge for future use.

Participants also explained that they only transfer small amounts of knowledge to their team; in some cases, they or their teams do not feel the need to gather knowledge, let alone transfer it. In addition, when Eco Design aware employees leave their company, their knowledge goes with them since there are in most cases no systems in place to capture knowledge and transfer it to the product development team or company. This problem of knowledge retention was experienced by the majority of cases.

20 years following Dewberry's research (1996), the current research encountered the same problems of sustained familiarisation (through dissemination of knowledge). While the participants in Dewberry's research thought being familiarised with environmental information would become easier over time, the current research shows this has not been the case. This is due to a clear lack of time dedicated to initial familiarisation with Eco Design knowledge and approaches, which thereby hinders any chance for improvements.

Drivers

The use of forums, meetings and other knowledge transfer methods from individuals to teams and from personal memory to collective repositories/physical libraries allows teams to sustain and grow Eco Design knowledge, experience and expertise.

Barriers

There is a lack of processes to collect and disseminate knowledge within the design team that limits implementation to those designers who are personally involved in Eco Design activities and rely solely on their memory.

Relying on personal memory leads to the loss of Eco Design capability (employee leaving), and to a slow knowledge growth across the team (on an individual basis).

Communication and Collaboration

Findings from the Explorative Stage

There is a lack of information received by design teams that hinders the understanding and implementation of the Eco Design strategies. This **lack of communication and collaboration** at design teams and product development teams levels that, while not confined to Eco Design, hinders the implementation of Eco Design.

Findings from the Corroborative Stage

There is a general lack of **communication and collaboration systems** in place (which reflect findings from 'F. Knowledge Transfer'). This is seen by the vast majority as a barrier to Eco Design. Managerial personnel can be **reticent** to implement communication and collaboration activities. These problems are exacerbated when it comes to Eco Design. These findings are in line with the findings from the previous research stage.

Participants were generally negative about the lack of collaboration and communication within projects. They explained that internally (within the design team), information filters down with some loss from senior levels and from the client companies. Externally, they also experience difficulties (such as time constraints and retention of information) in gathering information from the supply chain. When comparing the knowledge of environmental criteria from the different participants in each case; there seems to be a much greater loss of information (than for other product design criteria) down through the management hierarchy. Overall, it seems that the companies' environmental strategies as well as the products' environmental objectives are not effectively communicated down to the design team.

The problem of communication and collaboration affecting interviewees was not confined to Eco Design issues but generally applied to the design process. However, in Eco Design oriented projects, interviewees stated that these problems largely affected the capacity to achieve best Eco design performance. In many cases, interviewees reflecting on their practice felt that the lack of information, communication and collaboration often makes it impossible to achieve the desired environmental objectives.

As described in 7.2 Objectives, the research found a clear lack of cohesion and dialogue between design briefs' environmental objectives and the overall environmental objectives of a company. Most interviewees also observed a general lack of cohesion across the product development chain in terms of environmental strategy. Interviewees from design teams generally have a low engagement with suppliers and in most cases no engagement over environmental strategies. Gathering knowledge from suppliers on their processes and material use for example is difficult. It also seems difficult at a product development level to work with suppliers to adopt greener approaches. This lack of information and collaboration in turn makes the development of an environmental impact assessment of existing products as well as new concepts problematic. On the other hand and unhelpful to this situation, a majority of interviewees do not see it as part of their job to investigate these issues (see section 7.1, Responsibility). Information and communication were also found to be key to Eco Design by Dewberry (1996). However, 20 years later, little seems to have improved in this area.

18-Blue offered a different perspective on the subject. Strong communication channels between manufacturing, design, engineering and the environmental team assured the pursuit of common environmental goals throughout the design process. However, this was in many aspects an isolated case and therefore lacks strength for generalisation.

Drivers

Clear communication of environmental goals and objectives seems to enable and drive Eco Design implementation.

Barriers

Lack of communication between clients, the different stakeholders of the product development cycle and the design team hinders Eco Design (chances of) performance.

Implications

Subsequent to the identified lack of Eco Design adoption discussed in the previous section, this research has shown there is a lack of Eco Design knowledge, knowledge development and knowledge transfer in design teams. While practitioners are submerged by information daily, especially through online channels; this available knowledge is rarely vetted by recognised authorities. Such flow of information also only increases the difficulty finding appropriate information and the need to manage gathered knowledge on both individual and design team levels. There is a need for academics to work collaboratively to provide the industry with vetted, accepted and recognised knowledge. Individual content creation from research groups and industry only develops more for the practitioners to wade through, adding time to select information rather than assimilate it. Design teams suffer from a lack of knowledge transfer, especially in regards to Eco Design. Eco Design knowledge is gathered individually and because no systems are in place to disseminate this knowledge across design teams, knowledge development is not progressing. Again, this relates to a lack of process for gathering and managing knowledge. Each practitioner stores their repository of knowledge in their own way, which is inaccessible to the other members of the

team. The knowledge base of design teams is therefore difficult to assess and utilise, as the Eco Design capabilities are unknowingly locked in individuals. In turn, this is linked to problems of lack of communication and collaboration (as developed above). This is especially true between design teams and management who retain information from the design brief. Overall, this unorganised approach to knowledge and communication found across the industry creates strong barriers to innovation and Eco Design implementation.

7.4 Economic Climate

<p>Findings from the Explorative Stage</p> <p>The current economic climate (recession of the late 2000's) is generally seen as hindering factor.</p>	<p>Findings from the Corroborative Stage</p> <p>Not all cases feel influenced by the economic climate in terms of Eco Design implementation. Some influenced cases found the economic climate to be a barrier to Eco Design implementation, while others saw it as a driver. In cases not influenced by the economic climate, some cases simply did not consider Eco Design any more than before (all design consultancies). Only one case that already implemented Eco Design found the economic climate not to influence implementation.</p>
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While the first stage of the research found the recession of the late 2000's was a hindering factor in the implementation of Eco Design; the second stage showed a more complex picture with regards to the attitude participants have on Eco Design and also the language they use. In cases where Eco Design was synonymous with efficiency, the economic climate positively influenced Eco Design implementation; however, where it was perceived to add cost, the economic climate negatively influenced implementation (table 6.1).

<i>Eco Design was not being implemented</i>	
Because Eco Design is seen as an added cost , the economic climate is a stronger barrier to considering Eco Design implementation	Because Eco Design is seen as an advantage , the economic climate is a driver for Eco Design implementation
<i>Eco Design was being implemented</i>	
Because Eco Design is seen as an added cost , the economic climate is a barrier that stops Eco Design implementation	Because Eco Design is seen as an advantage , the economic climate is a driver for further Eco Design implementation

Table 7.1 – The different cases categories regarding the influence and effect of the economic climate (adapted from table 6.3).

The economic recession of the early 1990's is not mentioned within Dewberry's work (1996). However, there are several mentions of the critical need to keep prices and costs down that show that then and now, when costs go up or sales are down, interest in Eco Design goes down too.

<p>Drivers</p> <p>Difficult economic times can help in regards to efficiency; which in the case of certain energy-using products can help the implementation of Eco Design (but mostly efficiency) approaches. Times of economic growth allow for more budget to be spent on considered 'less vital' issues, such as Eco Design.</p>	<p>Barriers</p> <p>Difficult economic times can hinder the importance placed on lowering environmental impacts.</p>
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7.5 Overall Findings

Pro-active Vs Reactive Approaches

Cases that provided positive results in the implementation of Eco Design were also those that provided the most positive results in other themes. For example, it is interesting to note that the only case using an eco-tool was also the one appearing to use the most communication or collaboration tools (**14-Green**). The opposite is also true with cases lacking both implementation, positive views and organisational communication and collaboration (**16-Navy** and **17-Crimson**). These findings also emerged within Dewberry's research (1996). As the author explains: *"Attitude, awareness and action are very much interlinked"* (p.185); that corresponds here to views, ethics and responsibility (attitude), knowledge (awareness), and adoption and approaches (action).

Implications

Even today, Eco Design only remains an innovative process rather than a requirement. It is seen as an add-on 'optional' layer to the main Product Design process. It is therefore most often only encountered in pro-active companies implementing other fringe, innovative processes. This research has shown that companies have no interest in thorough and widespread Eco Design implementation and that the pro-active companies adopting Eco Design are part of a small minority. As such, there is a need to make Eco Design implementation a requirement through much stricter policies and regulations that for now have very limited impact on the design stage of products.

Information and Education

Knowledge (and the lack of) shaped a large part of the findings from this research (section 7.3). Participants expressed scepticism towards the discipline, perceiving it as an added cost and/or mistrusting its results. They explained that it was not part of their roles and that they lack time to develop knowledge, let alone disseminate it. The only members of the design teams researching the field were doing so in their own personal time. Because of this, the knowledge was in most cases neither catalogued nor disseminated. As seen in **08-Gold** and expressed by **1403**, this places the Eco Design knowledge base in a precarious state, where the departure of the knowledgeable green champion also means the loss of the knowledge and expertise.

Access to appropriate information was also a main problem in Dewberry's research 20 years ago (1996). Lots of educational content has been developed since, but unfortunately none have emerged as industry-standards. The problem is that regardless of the amount of content created (from basic to complex), there is a prerequisite lack of demand for Eco Design. Back then and still now, there remains a strong stigma regarding the potential involved costs to implementing Eco Design and therefore investing in learning and training on Eco Design.

Implications

While Eco Design demand and Eco Design as a regulatory requirement remains critical to Eco Design implementation; this research has shown that Eco Design initiatives from design teams is heavily hindered by a lack of appropriate and recognised information and training. This lack of standards also participates in the amount of misinformation encountered by design teams. A recognised and global standard would remedy the lack of trust expressed by the participants. It would also help greatly reduce the amount of time needed to adopt Eco Design. This is seen as the most essential aspect that the Eco Design academic field can and should be working towards.

Lack of demand, lack of motivation, lack of drivers, lack of 'need'

Companies selling products to consumers (which themselves have no financial responsibility vis-à-vis disposing of the product) have no altruistic interest in reducing the environmental impacts of their products' use and disposal life cycle phases. Therefore, the adoption of Eco Design (environmental aspects consideration added to the design process, while maintaining economic advantage) generally provides no more benefit to these scenarios than Efficiency or Lean Manufacturing (marketing benefits is seen as a potentially loaded gun by most). This is until a law, regulation or scheme is implemented to promote (e.g.: energy rated white goods) or enforce (e.g.: restricted substances laws) the lowering of environmental impacts. Only then does environmental advantage becomes a marketing and economic advantage and Eco Design can have a role to play that outweighs that of the role of Efficiency. There is simply no business sense in lowering environmental impacts with no or little economic benefit or to voluntarily extend businesses' own producer responsibility (to engage to lower environmental impacts for use, disposal and recycling stages).

The last 20 years in Eco Design research have seen the growth of literature on guidelines, frameworks, tools and so on. But the lack of prerequisite demand for such resources by industry indicates this to be a wrong direction of research. Unless taxed and/or regulated, companies do not have the need to implement Eco Design. And while all issues regarding the lack of communication between managers and designers and the lack of cohesive environmental strategies are valid points; there is simply no prerequisite motive for companies to implement Eco Design at or above the design team level.

As discussed in 7.1 and 7.2, most designers expressed they had little leeway to influence the briefs, and design consultancy especially explain they could not dictate to their clients to implement Eco Design. This was also a main finding of Dewberry's research (1996); which again shows a lack of progress over the last 20 years. However, this issue only pushes the dialogue on Eco Design demand and motivation to those clients and managers; which ultimately do not see the need to implement Eco Design, unless for regulatory or marketing purposes.

Implications

If there is no demand for Eco Design, developing tools and approaches for Eco design implementation is not going to grow demand. The academic field of Eco Design is in some sort of dead-end. Without the initial demand for Eco Design by companies and inclusion of Eco Design objectives in design briefs, there is little that design teams will be able to implement. Further academic work on methods and approaches will not result in any further Eco Design implementation. Understanding further the needs of design teams when adopting Eco Design will not put any more obligation on companies to implement Eco Design either. As this research has shown, incentives put forward by academics such as a potential competitive advantage have very little impact in persuading companies to implement Eco Design. Instead, there is a need to make Eco Design implementation a regulatory requirement because consumer demand, personal motivation and company interest (philanthropy or economic efficiency) are not strong enough drivers.

Efficiency Vs Eco Design

There is a strong and curious relationship between Eco Design and Efficiency. While pursuing efficiency (lowering the amount of components, reducing the energy use, reducing the amount of material used) often results in contributing to the environmental bottom line; this is very difficult to show. Indeed, the accounting of the environmental benefits is much more difficult to assess than the accounting of the economic savings, and therefore only very rarely occurs. Therefore, it is difficult to count efficiency as part of Eco Design, simply because the motivation and areas looked at are different. The majority of interviewees stated that Eco Design principles were taken on board only if the results made financial sense. In most cases, Eco Design is limited to efficiency where the product development team aims to reduce material use, energy consumption or packaging for economic motives. Sometimes, the environmental benefit is only a by-product

or a potential marketing tool. In some of the cases, interviewees explained that the opposite is also true. Inefficiencies in the product development process can make a product worse from an Eco Design point of view. In-house design teams expressed this view the most, stating that short timelines for example, had negative repercussions on the environmental aspects of their projects. Overall, there is very little done in the design industry that can be attributed to Eco Design (for environmental concern) rather than Efficiency (for savings concerns).

Implications

Design teams and companies do not operate based on altruistic incentives. Whilst one of Eco Design's objective is to not hinder economic costs, the term 'Eco' in Eco Design and the idea of reducing environmental impacts both generate negative feelings associated with extra cost. When implementing Eco Design, the assessment of environmental impacts before and after the design of a product does require knowledge, time, and therefore, monetary investment (especially, as discussed in section 2.5, in early phases of adoption). While this might be offset by the cost savings of the Eco Designed product, it is not necessarily the case.

Again, only legislation can make environmental assessment a requirement. Until such legislative changes, efficiency-related terminology may be a better motivator to get companies to engage with environmental impacts.

The following and remaining chapter concludes this thesis by presenting the object of the research, its contributions and the need for further research.

Chapter 8 - Conclusions

This chapter presents the conclusions of this research. First, the object of the research is reiterated and reflected upon (Section 8.1), before discussing methodological concerns (Section 8.2). Then, recommendations for the field of Eco Design research and for the Product Design industry are provided (Section 8.3), before presenting the research contributions to knowledge (Section 8.4), and lastly offering directions for future research (Section 8.5).

Introduction

While the previous chapter presented the findings of the research itself; this final chapter aims to summarise the undertakings of the research, to reflect on its contribution to knowledge and to provide recommendations for the industry and for future research.

8.1 Addressing the Object of the Research

The following section reiterates the object of the research presented in the first chapter (section 1.7) and presents an overview of the activities undertaken to fulfil the aim and objectives of the research.

Section 1.7, Research Aim, Objectives and Contributions:

*“The **aim** of this research is to review the level and type of Eco Design in the British Product Design industry and to identify recurrent themes helping or hindering implementation.” (p.17-18)*

*“**Objective 1** - To review the relevant literature on Eco Design approaches and tools as well as implementation and success factors;*

***Objective 2** - To undertake a pilot study to provide insights and directions for the research activities and its methodology;*

***Objective 3** - To explore the current level and type of Eco Design and recurrent themes helping or hindering implementation;*

***Objective 4** - To provide a sufficient breadth of data to validate findings across the British Product Design industry;*

***Objective 5** - To provide a critical overview of Eco Design implementation as well as recommendations for the industry.” (p.19)*

The aim of the research was presented, along with the research objectives in the first chapter of this thesis. In combination, addressing the objectives informed the overall aim of the research. The first objective, to review the literature, was fulfilled in the second chapter with an extensive and up-to-date literature review on Eco Design theory and current practices. The second objective was to undertake a pilot study and gather first insight and further direction for the research. This was achieved and presented in the fourth chapter. The third and fourth objectives, central to this research, were to undertake two separate investigations to explore and corroborate findings on the implementation of Eco Design in the Product Design industry. Chapter 5 and 6 presented these activities in depth, and demonstrated the process of collecting and analysing the data gathered. Finally, the fifth objective was to provide a critical overview of Eco Design from the findings of this investigation. This was achieved in chapter 7. In turn, this current chapter provides recommendations for practitioners and academics in the field of Eco Design and Product Design (section 8.2), and presents the contributions to knowledge made by the research (section 8.3).

8.2 Recommendations

This section follows on from the discussion of findings, drivers and barriers presented in the previous chapter and offers recommendations and avenues for improving Eco Design implementation in the Product Design industry. These recommendations results from the investigation and experience gathered during the research.

Education and Training

Themes involved: Views, Ethics, Responsibility, Good Design, Objectives, Adoption, Approaches, Knowledge, Communication and Collaboration, and Economic Climate.

The overall views of the participants in this research indicate that they believe Eco Design is an important part of Product Design in theory, but that they are powerless and unable to act in implementing Eco Design within their practices (see section 7.1). Design teams express that the responsibility lies within management, while management explain clients are not asking for it. This research has shown that the lack of environmental objectives in design briefs is often due to a fear that Eco Design may add cost. This perception needs to be addressed through raising awareness, education at all levels and through professional training. In addition, environmental impacts that are not going to be considered due to increased costs have to be addressed via legislation, through pressures and incentives (as developed below).

Lack of time, trust and knowledge were all witnessed throughout this research and were linked to a lack of primary Eco Design knowledge (see section 7.3). Educating product designers on Eco Design theory, approaches and strategies would also help implement Eco Design in design teams, as well as find and assess environmental alternatives during projects. This conclusion also echoes the research of Bocken et al. (2014), which found environmental knowledge to be essential for eco design implementation.

External Pressures and Incentives

Themes involved: Objectives, Adoption, and Knowledge.

As discussed in section 7.2 – Implications, the producer behind the design team is not often responsible for the product life stages at which environmental impacts occur. Overall, the Product Design industry and their clients (brands and manufacturing companies) have little sense of environmental responsibility over the impacts of their designs and products. While there are laws regulating for example, the use of toxic substances and while a few industries are more regulated than others (e.g.: the car manufacturing industry); this does not affect the vast majority of the designed goods in the industry (as seen by the lack of care for environmental impacts in this research). This research has demonstrated that this is one of the biggest barriers that hinders Eco Design adoption (see section 7.2).

As such, external pressures and incentives need to be put in place to motivate producers to implement Eco Design. The benefits of lowering environmental impacts need to be explained and promoted by governments and non-governmental organisations, and clearly presented to the different stakeholders involved, especially consumers. For example, the use phase of products typically yields the largest environmental impacts with energy-using devices. This energy cost during the use phase directly affects the consumers' bottom line; raising awareness on these issues and promoting products with lower environmental impacts can enable consumers to choose wisely and motivate companies to competitively reduce energy-use.

Through education and training, awareness needs to be raised amongst companies to highlight the economic benefits of lowering environmental impacts. Governments also need to incentivise the take up of these considerations and improvements by companies; especially because they are responsible for the handling of designed goods' end of life. Governments also need to externalise the responsibility of companies by regulating them further, through taxes and fines, into lowering environmental impacts.

Companies and Product Design teams will only have the incentives to lower the environmental impacts of their work by being held responsible for the impacts of their designs throughout their whole product life cycle.

Recognised and Rigorous Information and Standards

Themes involved: Time and Trust, Knowledge, and Knowledge Transfer.

Due to contradictory and confusing information, designers find it hard to access knowledge (see section 7.3). On one hand, there is a lack of trust in Eco Design alternatives and the industry is wary of making environmental marketing claims without tangible undeniable proofs (section 7.1). On the other hand, Product Design teams have very little time to research into innovative and new areas, such as Eco Design.

This research has shown that the Product Design industry is not in need of further tools or approaches to Eco Design, but is in need of reliable and accessible information and assessment standards (section 7.3). The search for alternative materials, processes and environmental strategies is too sparse or from unverified sources. There is also a lack of accessible recognised assessments of alternatives to be able to learn through comparisons. There is lastly no emerging standardised assessment tool for designers to use and depend on for their environmental decisions. A few exist, but they are not yet recognised by the industry.

There needs to be a push from a group of governments and/or an organisation such as the International Standards Organisation, to provide a set of approved recognised tools and stream of accessible and verified information on Eco Design. Only through a recognised and established source of knowledge, will the industry accept and trust Eco Design theory, approaches and alternatives, and be able to implement Eco Design within acceptable timescales.

Promote and Help Green Champions

Themes involved: Ethics, Responsibility and Approaches.

Green Champions across the research proved to be the Eco Design knowledge keeper of their design teams as well as the motivators and evangelists for Eco Design implementation. However, they were found to be frustrated by the lack of Eco Design implementation across their projects, and Product Design industry. They also feel alone in their Eco Design personal investment (section 7.1).

There could be a platform, added possibly to the source of information discussed above, where Green Champions would disseminate their findings, learn from others and communicate with their peers. Communication and collaboration between Green Champions from across the Product Design industry could strengthen each other's knowledge and experience, while reducing their frustration and feeling of isolation. They could in turn feed their learning and raise motivation within their own design teams and design projects.

Knowledge Dissemination

Themes involved: Time and Trust, Knowledge, Knowledge Transfer, Communication and Collaboration.

A significant internal barrier to Eco Design implementation encountered during the research relates to the lack of dissemination of Eco Design knowledge gathered during design projects. Knowledge development was shown to be highly individualistic and often lost through a lack of documentation and dissemination. While this problem was not specific to Eco Design knowledge; it was shown to be exacerbated on Eco Design matters and hindering long-term Eco Design implementation (see section 7.3).

The use of knowledge dissemination tools such as forums, digital and physical knowledge libraries, and themed meetings would highly increase the capabilities of a design team to implement and sustain implementation of Eco

Design. The sharing of Eco Design experience and knowledge within design teams is seen here as fundamental to long-term Eco Design implementation.

Design Teams Involvement

Themes involved: Communication and Collaboration.

Throughout the research, it was shown that designers are often not aware of the entirety of their clients' brief, and of the environmental strategies from their clients (theme Collaboration and Communication). There is a loss of knowledge through management hierarchy that was shown to hinder Eco Design implementation, by making designers unable to focus on the right environmental strategies (see section 7.3). This design teams' lack of involvement by higher management was also seen to be a problem for traditional design brief criteria. But again, in the case on environmental strategies and objectives, the lack of communication and collaboration was much stronger, and often meant not reaching environmental criteria.

Design teams need much more knowledge of and involvement in their clients' environmental strategies, as it is clear from the literature that a very large portion of the environmental impact of a product is determined during the early design stages (see section 2.3). Designers need to be made aware of these criteria, but also need to collaborate with the environmental units of their projects' attached company to better achieve Eco Design.

8.3 Contributions

This section discusses the different types of contributions to knowledge this research has made to the Eco Design discipline and to the Product Design industry.

This research has contributed to the development of Eco Design knowledge in regards to the understanding of its practices in industry. These contributions can be organised in three sections. The research first made substantial knowledge contributions to the Eco Design discipline. The research identified the current Eco Design practices of the Product Design industry in the UK. It also identified from its investigations the drivers and barriers to implementing and sustaining Eco Design, and made subsequent recommendations for both the industry and the academic research in the area (above in section 8.3). Secondly, the research made timely literature contributions by disseminating the findings of the research through the publication of conference papers and peer-reviewed journal articles (see the publications section of this thesis). Thirdly, the research made methodological contributions to the field of Eco Design research. The devised methodology for this research indeed used a large-scale, two stage case study design; comprising of one of the largest researched sample of British Product Design teams for an in-depth qualitative enquiry undertaken to date (e.g.: over 80% of product design consultancies in terms of British market share were interviewed, as explained in section 8.2). The originality of this research design and therefore contribution lies in the scale of the study (rather than the methods used).

Overall, this research provided a basis for understanding of the state of Eco Design implementation and practices in the UK and a basis for conducting research on Eco Design implementation and practices in regards to the future state of British Eco Design or in regards to current practices in other geographical settings. In doing so, this research also provides a basis for future research, developing tools and frameworks for enabling Eco Design implementation in the UK.

8.4 Future Needs

This final section introduces, following this research and its findings, recommendations for future research for the field of research as well as to supplement this research.

Further Research

Additional investigation could further strengthen the findings of this research in terms of breadth and depth. More cases could be analysed, to allow for greater granularity of findings and to further strengthen their external validity. Repeating the research at a more recent point in time (through a longitudinal case study design) could provide further findings on the evolution of Eco Design implementation within cases (an option which was not feasible within the constraints of this research, in particular with regard to the availability of the participants). It would also be interesting to replicate the research in a different geographical setting to observe the differences between practices across countries.

Further research, using a different set of methods, could also add to the depth of the analysis. Ethnographic and participant observation (see section 3.5) could for example be carried out with design teams to observe in-situ the process of Eco Design within projects.

Future Research

Having observed a lack of use of Eco Design academically designed approaches and tools; it is clear that research needs to steer away from the development of new implementation tools and process description tools. Having also observed in design teams a lack of trust in environmental alternatives and a lack of time to develop Eco Design knowledge; it seems clear that product designers need a recognised and rigorous source of Information and standards to rely on.

Research should first focus on developing environmental information on materials, products, technologies (but also Eco Design education) that comes from

assessments approved by the scientific community. It is this lack of recognition and trust that research should be addressing, possibly through the development of an international standard of assessment. While certain organisations have such standards and certification, none of these have emerged as a serious international contender (e.g.: Cradle to Cradle certification, McDonough and Braungart (2014)). Research should secondly focus on knowledge-sharing platform, for design teams to exchange their findings, ideas and experiences. The research in progress of Baouch et al. (2014) is a good example of this, currently identifying requirements for such platforms. Research could then focus on tools for the different discipline involved in Eco Design, all using the same developed standards, all able to communicate with one another.

Conclusions

The biggest problem faced by our society in regards to Sustainable Development is the lack of adoption of Eco Design by design teams. This research has demonstrated that very little has changed over the last 20 years in this area, and that the academic development of Eco Design approaches has had little influence in practice. Academic research needs to stir away from tool development, advanced Eco Design implementation and from theorising Eco Design. What the Product Design community needs is access to relevant and accessible knowledge. The legislative efforts (discussed in chapter 1) have also had little repercussions on the practice of design teams and the implementation of Eco Design. This is simply because producers of goods still have nowadays only little responsibility over the life stages of the products they design. Governments and policy research needs to be at the forefront of this issue, by developing incentives and pressures and by giving more responsibilities to companies and their design teams. Only by making the lowering of environmental impacts a regulatory requirement, will we achieve the implementation of Eco Design across the British Product Design industry.

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